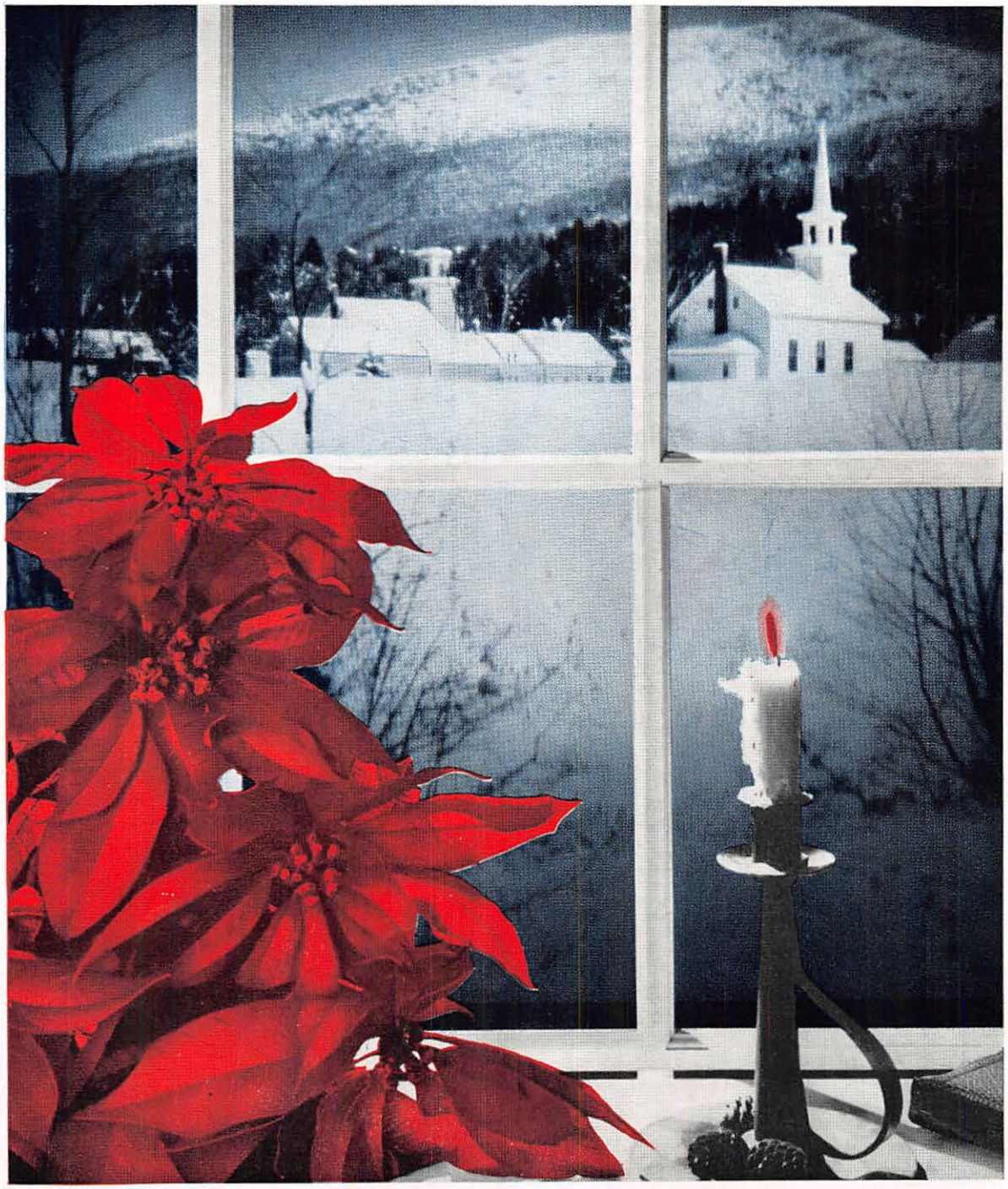
DECEMBER 1968

Railway Signaling & Communications

May Christmas last forever!



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1. MAGNETIC DETECTOR: A non-mechanical device used to detect motion and direction . . . release control of electric switch locks . . . track component of speed determining circuits . . . control yard TV or cameras . . . track component for car counters, etc. **Ask for MD-10 Bulletin.**

2. CLEARANCE: Detection of both high and wide loads by a solid state receiver which senses the interruption of a transmitted beam. **Ask for CD-10-5 Bulletin.**

3. HIGH WATER: Detection through the dependable resistance bridge principle. No moving parts to become defective through rust and corrosive action resulting from intermittent flood water exposure. **Ask for No. 514-1 Bulletin.**

4. LOOSE WHEELS: Detected in passing by the sensing unit on each track that triggers an indicating relay. **Ask for LWD-10 Bulletin.**

5. SNOW: Snow and/or freezing rain is detected when the ambient temperature falls below a predetermined value. **Ask for SD-10 Bulletin.**

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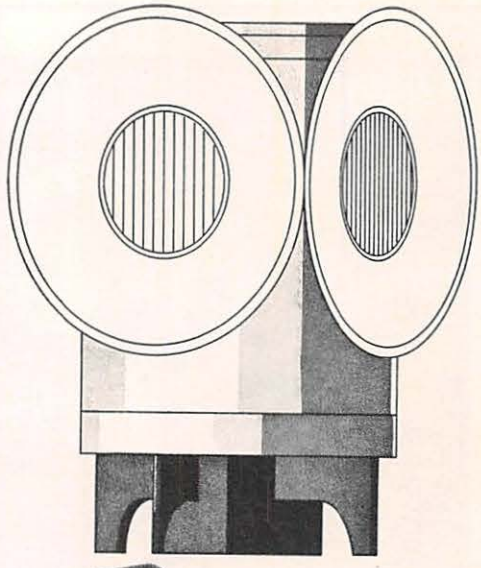

PLACE IT...
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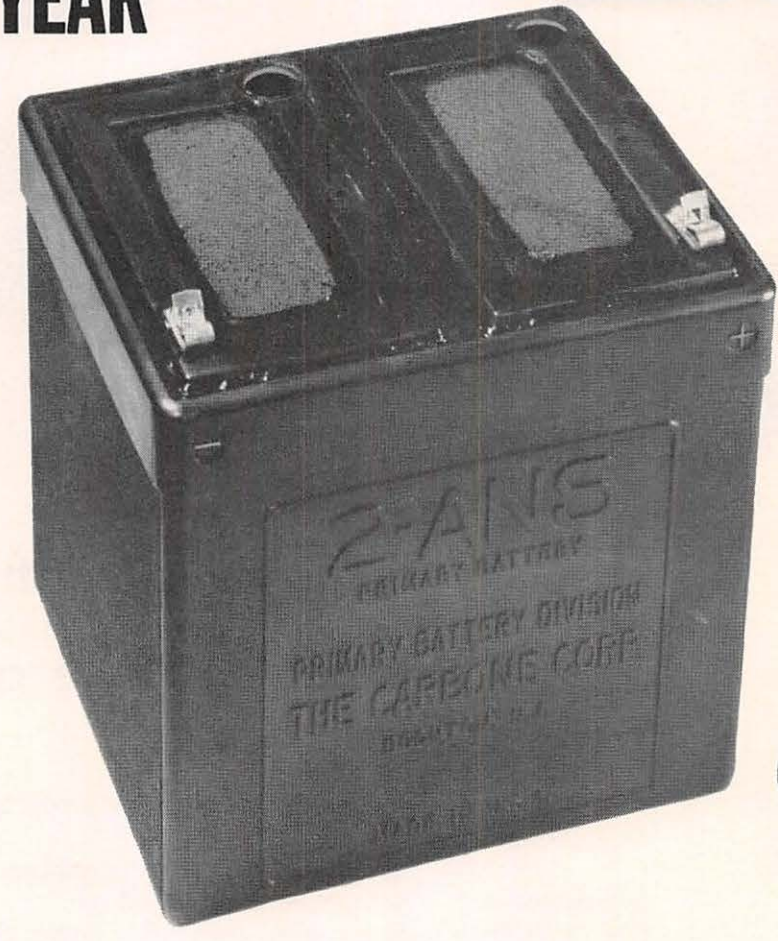

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3440

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Editor's Corner

The language used by the National Transportation Safety Board in some of its reports on investigations of highway-railroad grade crossing accidents is disturbing. For example, from its Sept. 18, 1968 report about an accident at Waterloo, Neb., the NTSB stated that a school bus "was driven across an unprotected crossing . . ." In a footnote, the report states that "For the purpose of this report, 'unprotected highway grade crossings' are those crossings where there are no devices installed or watchmen in attendance for the purpose of advising motorists and pedestrians of the approach of trains." A crossbuck and arterial stop sign were located at each side of the crossing facing toward approaching vehicular traffic.

Seems to me that a crossbuck and a Stop sign are protection devices. They warn approaching motorists of potential danger. The loose use of language bothers me because the Board's report implies that this crossing was unprotected and therefore unsafe. Also, unfortunately, the railroad gets blamed for these accidents.

In its Jan. 15, 1968 report about an accident in Sacramento, Calif., NTSB, in effect, called the crossing a potential "booby trap." Evidence indicated that flashing-lights were operating, but the driver ignored them, passed other cars waiting at the crossing, and drove into the path of a freight train.

One of the Board's conclusions was that "wide variation in warning times, false warnings and unclear and misleading warnings caused by switching operations existed from time to time at this crossing. Taken with the general industrial and railroad yard atmosphere, the result was a potential 'booby trap' for motorists."

This is one way to grab attention with scare tactics. Newspaper headline writers would have a field day with this report. Such language, from a governmental agency, supposedly charged with fostering safety, does not help the cause or make for an atmosphere of confidence, trust and cooperation among the parties involved, namely governmental agencies and the railroads.

To the Board's credit, it does recommend that this safety problem be studied by various governmental, educational and transportation agencies and companies. A key question to be asked: How much is the motoring public willing to pay for maximum railroad-highway grade crossing protection with minimum delays to itself. The technology is now available to provide proper and accurate warning times to motorists that trains are approaching.

Hopefully, the National Transportation Safety Board will be more factual and careful in its reporting on accidents.

Bob McKnight

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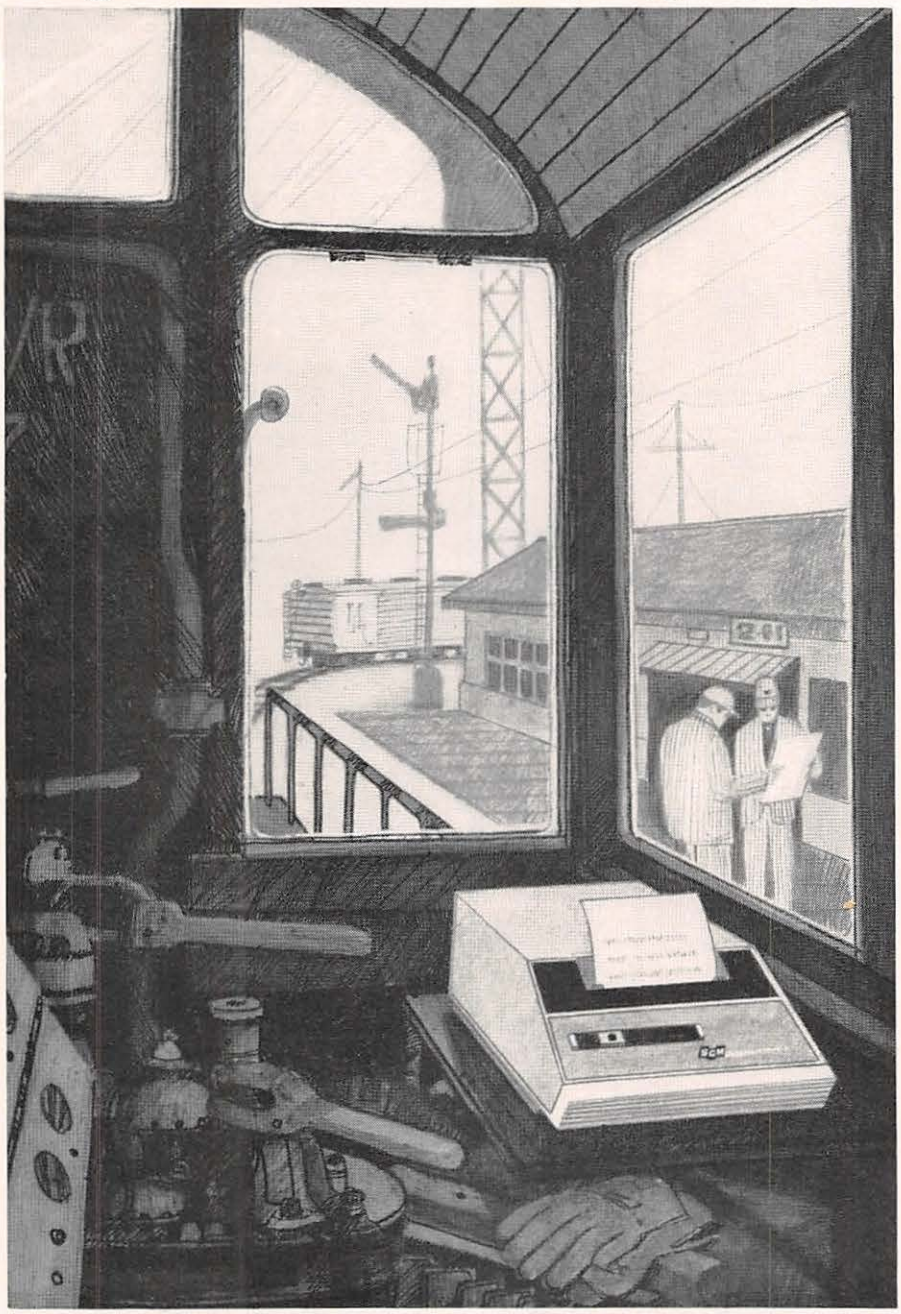

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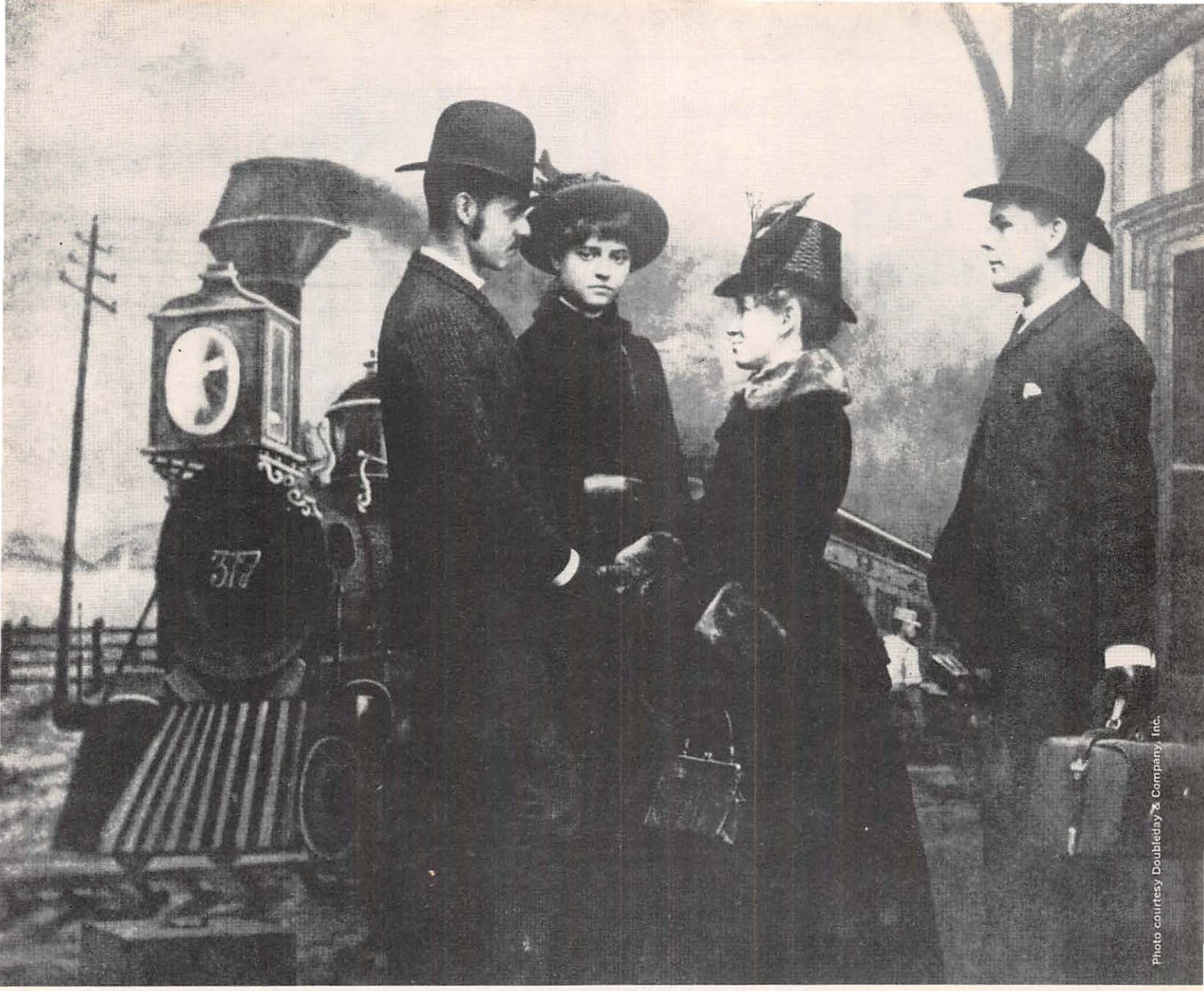

"...and don't fret, Millicent—they tell me this fine railway is fully equipped with Servo's reliable, plug-in safety type relays."

Too bad we weren't actually on the scene in the 19th century—it would have given us a nice, warm feeling to know that the presence of our products could help reassure sweet Millicent and her beau.

For the modern railroads of the 20th century, we've developed an improved new series of plug-in safety type signal relays. They have been designed to meet or exceed all the requirements of AAR Specification 204 (Part 77), and are ideal for a wide variety of vital circuit applications. Special emphasis has been placed on fail-safe operation and complete circuit isolation. A major feature of these new relays is their unique contact design, which combines the high stability of molded-in, non-fusing contacts with the convenience of being able to insert or remove individual contacts when required. A versatile mounting arrangement permits the relay to be used as a plug-in unit—or installed as a shelf-type relay.

Can these new relays help reassure you about your vital circuit applications? We think so. To find out for yourself, send for Tech Data Publication 2017.

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Slow Release Relay
SS-110
Heavy Duty Contact Relay
SS-115
Power Transfer Relay
SS-120
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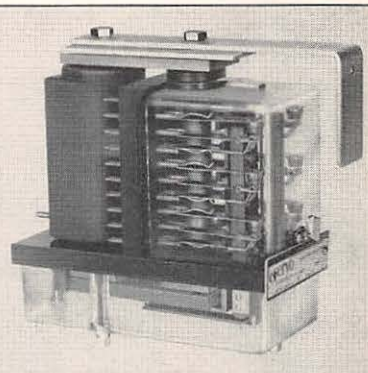

Plug-In Safety Type Signal Relay employs rugged, high efficiency magnetic circuit. Front contacts are silver making against non-fusing silver-impregnated carbon. Electrical breakdown voltage is 3000 volts AC minimum. Other design and construction features include: liberal electrical creepage and air gap; gravity release armature; nickel plated contacts; high strength phenolic contact adjustment ladders; impact-resistant encapsulated coil.

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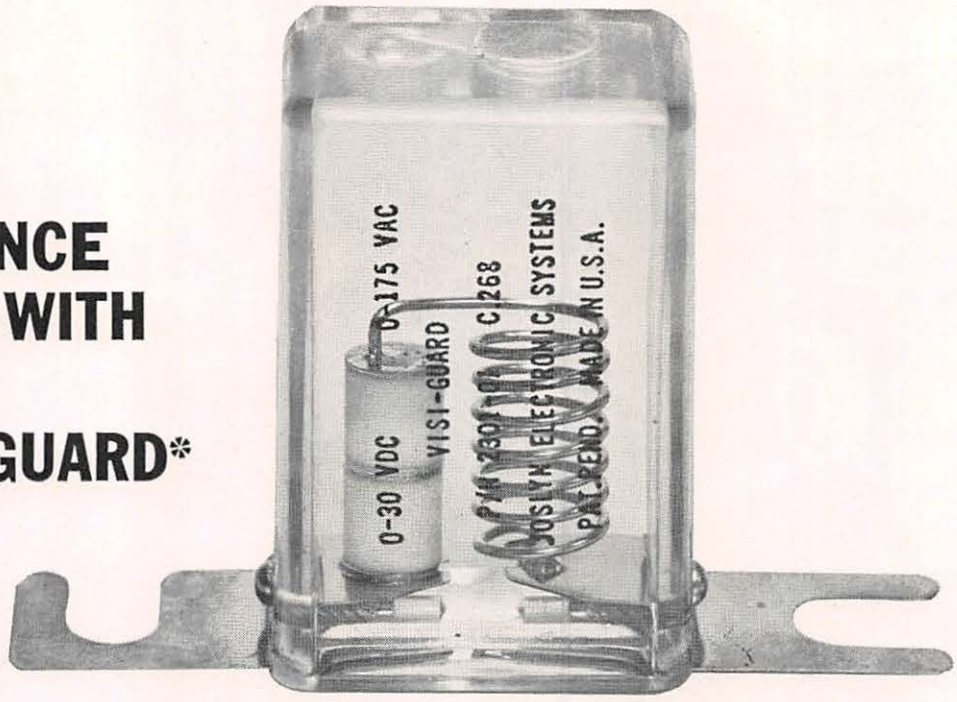

How much time and money, maintenance-wise, do false restrictive failures due to transients in the electronics cost you? Chances are, plenty! Worse yet, the problem they cause for you is compounded when you factor in the cost of disrupted schedules.

Now you can virtually eliminate those damaging transients up to 50 times or more every time they hit your electronics! Joslyn's new lightning and electrical signal type surge arrester — the 2300 series VISI-GUARD — protects your signaling equipment against larger surges and more often than any other means you presently may be using.

Breakdown voltage – 500 v peak. Response time as fast as 0.15μs at 10 kv per μs rate-of-rise. A minimum of 50 rated operations each consisting of a 5,000 ampere discharge current (10 x 20μs waveshape) and resulting power-follow current which automatically extinguishes. Another plus feature: extreme duty discharge capacity of 15,000 amperes 10 x 20μs waveshape.

The Josyln VISI-GUARD is dimensionally designed to directly replace existing arresters using any base including the molded plastic base, or AAR porcelain base, or the three-post porcelain base.

The price for protection has to be considered, of course. But if a device doesn't work, why buy it? With VISI-GUARD you know it will work. For that assurance, $8.60 each in quantities of 100 to 299 is low. VISI-GUARD — the device that frees maintainers for other problems. Another quality product in Joslyn's full line of electronic surge protection equipment for electronic systems. Write today for new JES 140 brochure. Joslyn Electronic Systems, Santa Barbara Research Park, P.O. Box 817, Goleta, Calif. 93017. Tel. (805) 968-3551.

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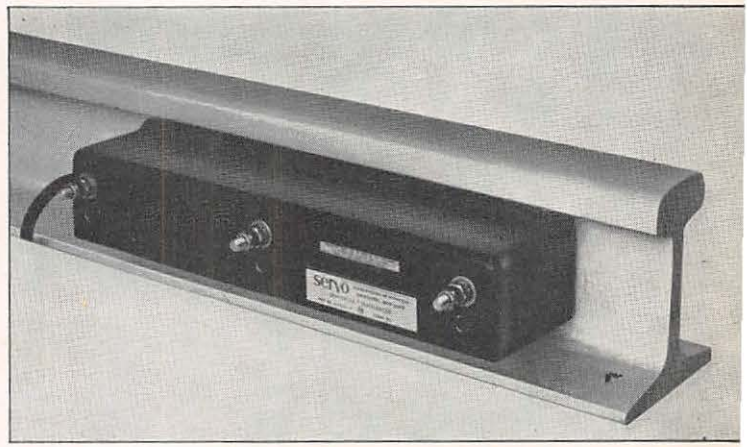
SERVOPOLE® and SERVOTRIP® rail-mounted transducers are variable reluctance magnetic sensing units capable of detecting wheel presence on railroad rolling stock. Passage of a wheel over the transducer generates sufficient power to energize a relay directly, without signal amplification. Actual contact with the wheel flange is not required. These new transducers have been designed to serve as basic building blocks for a wide variety of railroad control systems. Typical applications include: speed selective grade crossing controls; transducer track circuits; grade crossing restart control; track shunting; classification yard carstop retarder control; car and train arrival annunciators; car and axle counting; train length measurement; speed and acceleration measurements. In each of these and many other applications, the basic signal to the control system is simply and reliably derived from the magnetic transducer, which operates completely independent of track ballast conditions.

Would you like to know more about these versatile units, including technical description, specifications and application notes? Just ask for Tech Data Publication 2016.



SERVOPOLE® Rail-Mounted Magnetic Sensing Transducer is a dual-segment unit for use where directional information is required. Another model, SERVOTRIP®, is a single-segment transducer for applications where direction sensing is not required. The transducers have no moving parts—all internal components are encapsulated and mounted in a rugged fiberglass-reinforced housing. A complete selection of associated control units is also available from Servo, including: timers, directional sensors and analyzers, speed selectors, relays, etc.

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News Briefs

J. D. MacQuarrie
Canadian Pacific

Robert W. Margsh
C&O/B&O

• CANADIAN NATIONAL has awarded a contract to Servo Corp. of America in excess of $300,000 for several hotbox detector systems.

• SOUTHERN has placed a $1.9 million order for 802 Motran/VHF mobile radio units and 1,120 PT-200 portable radio units with Motorola Communications & Electronics Inc.

Southern is planning to install KarTrak ACI scanners at 38 locations along its lines during 1969.

• UNION RAILROAD has ordered an improved computer traffic control system from the Signal & Communications division of WABCO for installation at Duquesne, Pa.

• BANGOR & AROOSTOOK: **Hiram E. Childers,** signal supervisor, B&O/C&O, Staten Island, N.Y., has been appointed superintendent of signals and communications, succeeding **Thomas W. Cudhea,** retired.

Mr. Cudhea, a native of Spring Hill, Nova Scotia, has served as superintendent S&C since 1949. Previously, he had been employed by the Northern Telegraph Co., first as an inspector, and later as general foremen.

Mr. Childers began his railroad career with the B&O in 1941 as a signal helper.

• CANADIAN PACIFIC: **J. D. MacQuarrie,** general outside plant and standards engineer has retired.

• CHESAPEAKE & OHIO/BALTIMORE & OHIO: **Gary J. Bowerman,** signal maintainer, appointed signal application engineer at Huntington, W.Va. **James W. Briggs,** assistant signal supervisor, Walkerton, Ind., promoted to supervisor signal construction at Pittsburgh, Pa. **Jon A. King** appointed signal application engineer at Huntington.

Robert W. Margsh, engineer signal materials and standards, has retired. Mr. Margsh was born on Feb. 18, 1906 in Philadelphia, Pa. He began his railroad career in 1926 as assistant signalman on the Pere Marquette (now C&O). He advanced in the signal department to the position of signal supervisor in 1942. Two years later he was promoted to circuit designer. In 1945, Mr. Margsh was appointed assistant engineer, becoming assistant signal engineer at Detroit, Mich., in 1949. Mr. Margsh was promoted to signal engineer there in 1961. Subsequently, he was appointed engineer signal materials and standards at Huntington, W.Va.

• FLORIDA EAST COAST: **N. E. Decker** promoted to circuit engineer with headquarters at New Smyrna Beach, Fla.

• ILLINOIS CENTRAL: **Jesse C. Ramage,** engineer construction and maintenance-communications, has retired.

• LOUISVILLE & NASHVILLE: **J. D. Wyatt,** acting assistant signal supervisor, has been appointed assistant signal supervisor, Nashville, Tenn., succeeding **K. K. Tant,** who has retired on disability.

• NORTHERN PACIFIC: **Rueben Mueller** appointed assistant general foreman-communications at Seattle, Wash. **J. A. Carlson** appointed office manager-communications at St. Paul, Minn.

• READING: **John J. Foster,** chief signal, electrical and communications engineer, appointed manager-engineering department-signals, electrical & communications. **Clarence P. Moyer,** assistant electronics engineer, appointed assistant communications engineer, with headquarters at Reading, Pa.

Mr. Foster was born on Feb. 27, 1927 in Philadelphia, Pa. He received a bachelor of electrical engineering degree from Villanova College in 1949 and a master's degree in business administration from the University of Pittsburgh in 1960. In 1949 Mr. Foster joined the Pennsylvania's mechanical department as a junior engineer. In 1956, he became a power and control engineer for Jones & Laughlin Steel Co. In 1960, he joined Reading as a technical assistant engineer. Subsequently he served as a general foreman Reading locomotive shop, cost & budget engineer superintendent-plann ng & control and general mechanical superintendent, all in the mechanical and rolling equipment department. In 1967, Mr. Foster was appointed assistant chief signal, electrical and communications engineer, and earlier this year succeeded **George B. Blatt,** retired, as chief signal, electrical and communications engineer.

• SERVO CORP. OF AMERICA and GENERAL ELECTRIC CO. jointly announced that the long-standing litigation between them concerning hotbox detectors has been settled. "Under the settlement, Servo's suit now pending in the U.S. district court for the western district of Virginia has been concluded by consent. There is no other litigation between the parties on the subject matter." the announcement said.

• WESTINGHOUSE AIR BRAKE CO.: **C. D. Howell,** vice president and general manager, Signal & Communications division, has been elected to the new position of vice-president and group executive- general industry. **Walter P. Cartun,** vice-president and general manager, Air Brake division, elected to the newly created position of vice-president and group executive- transportation. **C. Benjamin Ramsdell,** vice-president marketing, S&C division elected vice-president and general manager, S&C division.

Robert H. Burton has been appointed sales engineer in the Chicago office of the S&C division. Mr. Burton was born in Chicago, Ill. on Sept. 10, 1937. He began his railroad career with the Milwaukee Road as an assistant signal maintainer. Subsequently, he was promoted to signal maintainer, draftsman and signal inspector. In April 1968, he joined Western Railroad Supply Co.'s S&C division engineering staff.

James W. Siburt has been appointed communications sales engineer, S&C division, with headquarters in Swissvale, Pa. He has had 20 years' experience in the communications industry with Radiation Service Co., where he held positions from service technician to regional manager.

Jesse C. Ramage
Illinois Central

John J. Foster
Reading

C. B. Ramsdell
S&C div. WABCO

W. P. Cartun
Westinghouse AB Co.

Robert H. Burton
S&C div. WABCO

James W. Siburt
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Circle 12 on reader service card on page 38

NP communications planned for future

Final testing is now being carried out by Northern Pacific communications forces on the last leg of its 1,724-mile microwave system. Equipment at the Seattle, Wash., King Street station terminal site is getting its final check-up before the entire microwave system is in full operation early next year.

The $8.5 million microwave system is but a part, admittedly the major portion, of NP's new communications plant. Additionally, some $500,000 is being spent for 4-wire telephone switching equipment that will provide improved dial telephone service. A feature of this telephone equipment is that it will provide 6-digit universal numbering for all NP offices.

As far back as 1964, Donald C. Hill, NP's superintendent of communications, realized that the growth of real-time, on-line computing, the rise in dial telephone usage and increasing data transmission would overtax the road's pole lines with its wire-line carrier facilities. Thus, Hill and his communications engineers began a two-year study, engineering and planning project. Part of this work involved a study of the trends in communications usage on NP, and what would be the requirements in 5 to 10 years.

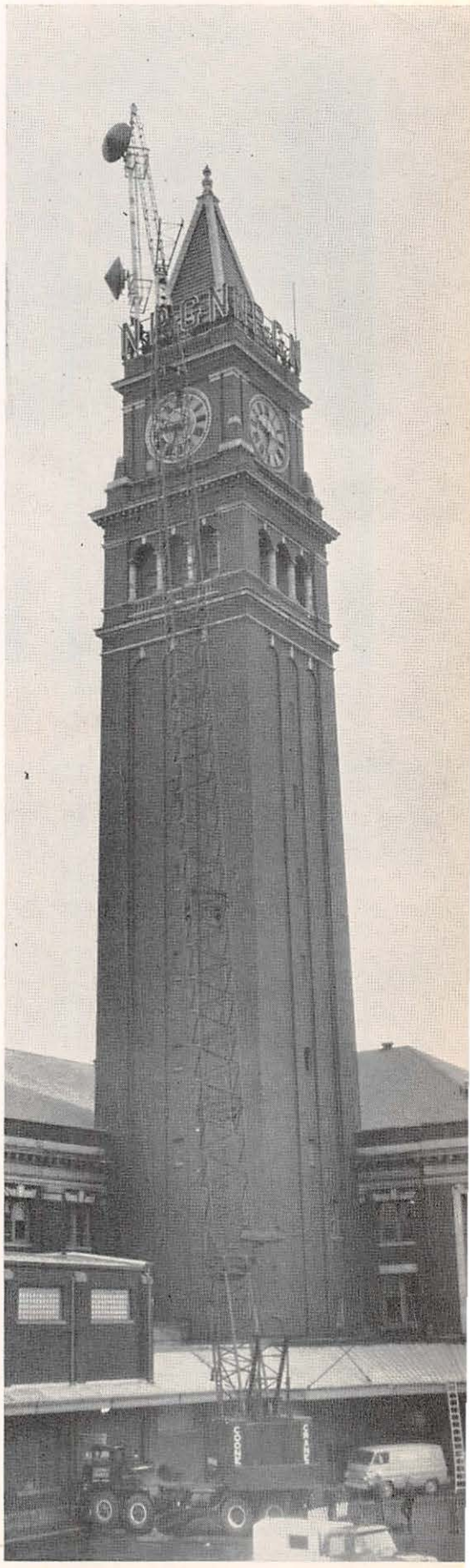
Because all signs pointed to tremendous growth, Hill and his group decided that the road must turn to microwave or leased circuits from telephone and telegraph companies. Using a 10-year base period, the communications feasibility study indicated that it would be more economical for NP to install its own microwave system rather than use leased circuits.

Interchange information from NP yards and junctions is now sent to the road's computer center in St. Paul. Some of this information comes into St. Paul via 100 word-per-minute Teletype, from 17 yards and offices via IBM 1050 units. NP has, on order or in service, eight IBM 2780 transmission units that can send data at the rate of 75 cards/minute as compared to only 7.5 cards/minute for a 1050 unit.

Presently, NP has an IBM 360/40 central computer, but it is planning for a 360/65 with a 2703 communications control unit. Frank H. Coyne, vice-president, management services, says NP is rapidly working toward an on-line, real-time computer operation with the associated management information network. The early 1969 in-service date of the St. Paul-Seattle microwave system will give Coyne that big bulk communications pipe that he will need for his MIS network. And it won't be a bit too soon, because the road's terminal performance control programs are being implemented at several yards, such as Laurel, Mont. Here, the 2780 unit is being used for high-speed data transmission to St. Paul's central computer. Also, the computer sends reports back to the Laurel yard at the same rate of 75 cards/minute.

NP is now designing a second-generation control system for its Pasco, Wash., retarder classification yard. A digital computer will be used for route selection and inventory of cars in the yard and terminal area. Louis W. Menk, NP president, says: "Interface with the central computer system at St. Paul will be accomplished by the use of IBM card devices, but some of our more optimistic planners foresee the day when direct communication between St. Paul and Pasco computers will enable transmission of advance consists without the card buffer.

"Terminal performance control will be processed at the central computer rather than at the yard because we have concluded that this is the more logical way to do it. Here, then, is a combination of new technology in yard control with an on-line, real-time in-



Crane with a 265-ft boom swings NP's western terminal microwave station tower into place on King Street station clock tower in Seattle, Wash.

NP's district supervisor Ed Bruce; Fred Childs and Don Hill inspect Rimrock, Mont. microwave.

formation system, each increasing the other's capability," Menk said.

In addition to providing the bulk communications so necessary to NP's present and future operations, microwave has provided these benefits:

- Enabled the removal of over 4,000 miles of line wire.
- Enabled the removal of over 7,000 crossarms.
- Provided the circuits necessary to enable consolidation of dispatchers from Fargo, Minneapolis and Duluth divisions. Further dispatcher consolidations are planned for the rest of the NP system.
- Permitted the removal of at least 50 miles of pole line.
- Capability of handling facsimile transmission, although not planned for the present. High-speed facsimile (6 seconds to transmit a waybill), takes about 40-60 voice channels. Hill says that development now underway on bandwidth compression techniques point to the possibility of operating high-speed facsimile in only a 20-voice channel bandwidth. As for the NP, it will be a wait-and-watch attitude.

NP's St. Paul-Seattle microwave system stretches 1,724 miles along its mainlines and consists of 85 stations . . . 16 terminals, 57 repeaters, 10 three-way junctions and 2 four-way junctions. Microwave system installation by Collins Radio Co., included all construction and installation work, plus training of NP electronic technicians in microwave maintenance and testing.

NP bought or leased land for the stations, and made a preliminary microwave path survey with Collins engineers. In most instances, the microwave station is off the railroad right-of-way because the prime criteria for a station site was to gain elevation. Because microwave is line-of-sight transmission from station to station, the higher a station can be placed, the shorter the antenna tower can be to overcome natural and man-made obstacles.

NP's microwave system did not come into being by the railroad giving Collins one big contract, then sitting back and waiting for Collins to hand it over ready for use. Using U.S. Geological Survey maps, plus on-site inspections, Collins and NP made the initial microwave path survey. Once likely sites were tentatively picked out, NP's industrial development department went into action to either buy or lease the proposed microwave station land sites.

After the survey of the St. Paul-Fargo section had been surveyed (about 250 miles), Hill requested money for the microwave equipment and also for funds to proceed with the path survey to Billings, Mont. At this time, he filed construction permits with the FCC for the St. Paul-Fargo section.

The next surveyed section was from Fargo, N.D. to Billings, Mont. (about 600 miles via microwave path). When this survey was completed, Hill again requested funds for microwave system construction, and for survey funds for completing the work from Billings to Seattle. Also, FCC construction permits were filed for the Fargo-Billings section. Similar procedures were followed when the Billings-Seattle survey was completed.

To gain clearance over hills, trees, buildings, etc., NP's microwave system often makes use of hills and buildings for station sites. In congested areas, such as NP's Northtown yard, Minneapolis, a self-supporting 240 ft tower is used to hold the microwave dish antennas. At the road's St. Paul headquarters, the antennas are mounted atop the general office building. At the other end of the system, Seattle, the microwave antennas are 250 ft above sea level being mounted on a 52-ft tower on the King Street station clock tower.

Between these extremes, 4-sided self-supporting and 3-sided guyed towers range in height from 30 to 300 ft. It's an economic choice, says Hill, as regards self-supporting vs guyed towers. Self-supporting towers are more expensive, but they do not require as much land. For example, the 240 ft self-supporting tower at Northtown yard requires only a plot of land 40 ft square. A 100 ft guyed tower would require a plot about 120 ft square to accommodate the guys which would be anchored at least 80 ft out from the base of the tower.

Most towers in the NP system are guyed. The towers required are painted red and white and lighted to conform to FAA regulations. Towers over 170 ft high are equipped with FAA approved aircraft beacons. These 620-watt, flashing-red lamps have dual bulbs so that if one fails, the second bulb will provide light. NP has contracted for a tower inspection service which will be made annually. Included in the service is changing of tower lights and beacon bulbs.

Most microwave repeater and junction stations are housed in concrete buildings, mainly because they are usually off the right-of-way. Most terminal stations are in railroad buildings because that is where the communications is required.

These concrete buildings have electric heating, air conditioning and lighting, being fed commercial power at 220 volts, single phase, 60 Hz, AC. At locations not near metropolitan areas where commercial power is considered very reliable, standby power equipment is provided. At conventional repeater stations, an Onan 12 kw diesel-engine generator is used to provide 220 volts AC when the commercial supply fails. For higher power requirements at three-way junction stations, a 15 kw plant is provided. In the Cascade mountains in Washington, some sta-

tions are at elevations up to 4,600 ft. Such stations are provided with 30 kw standby plants because of the combination of elevation and difficulty of access during winter months.

Where standby power plants are installed, they are in a separate room in the building. A cement block wall with a steel clad door is a partition wall so that noise and vibration from the generator is kept away from the equipment room containing microwave units, batteries and battery chargers. The generator room has a separate air intake for the unit and a louvered window contains a fan which operates to exhaust air and fumes when the generator is operating. The heavier 30 kw diesel-engine generators are bolted to the concrete floor. So far, NP reports, they have had no creeping by the 12 and 15 kw sets.

In the equipment room, the microwave racks are bolted to the floor with expansion bolts. The floors are covered with asphalt tile with a rubber covering along the baseboard. A small workbench and stool are provided for the radio maintainer.

The MW-308D Collins microwave equipment operates off 24 volts DC, being provided by rectified AC or C&D lead-calcium batteries. Warren Mfg. Co. dual battery chargers are used. A separate battery is provided for starting the standby power generator.

When the AC fails (commercial power), batteries take over operation of the microwave. Upon failure, almost instantaneously, the diesel-engine generator is automatically started. After about 5 to 7 minutes of running, the load is transferred from battery to the AC mode, that is, rectified AC. The time delay is to allow the generator to be providing full 220 volts AC output and the engine to be operating at proper speed.

Sufficient battery power is furnished to operate the RF portion of the microwave equipment for about 10-12 hours. To further reduce battery usage, the tower lights operate on AC only. Thus, during a commercial power failure, they would only be out for about 5-7 minutes, or until the standby generator took over.

To insure that the standby power equipment is operative, all diesel-engine generators are automatically timed to be started once each week and operate at full load for 20 min.

To prevent illegal entry and protect the housings and guyed tower support wires, a 10 ft high chain-link fence surrounds all microwave station buildings and the ground anchors of guyed towers. Fence gates are padlocked as are building doors.

For the St. Paul-Fargo section, Rohn Mfg. Co. towers were installed. From Fargo to Seattle, towers were furnished by K&B Co. of Dallas, Tex. Dish antennas, elliptical waveguides and dehydrators were furnished by Andrew Corp.

NP is using the FA-102 supervisory system for alarm functions. Eleven functions, conditions or equipments are being alarmed: (1) AC failure; (2) major battery charger; (3) major equipment- transmitter/receiver; (4) tower lighting; (5) high-low temperature in building; (6) illegal entry, (7) low fuel for standby generator plant; (8) dehydrator on waveguide (7-8 psi); (9) generator-run; (10) minor battery charger-standby unit; (11) minor equipment- standby transmitter/receiver.

Alarm indications, red light for a fault, green light for proper operation of the system, are brought into eight locations: St. Paul, Fargo, Glendive, Billings, Livingston, Missoula, Spokane and Seattle. Wire chiefs are located at all these points except Billings. When an alarm is indicated . . . for a particular station for a particular function . . . the red light is illuminated and a buzzer sounds. Normal practice is for the wire chief to cut out the buzzer, and of

Fault alarm system using tones operates continuously

Data transmissions for fault reporting are accomplished by a series of low-level tone bursts from the data transmitter which form a pulse train. These tone bursts are normally bridged directly onto the baseband at a nominal level of —13 to —18 dbm0 for modulation of the RF carrier. A pulse is generated when one of the transmitter data inputs is grounded. The data receiver detects either the presence or absence of the pulse at a given time segment of the pulse train. The presence of the pulse and its position on a synchronized time scale identifies the reporting transmitter data stage to which the ground, caused by a fault, is connected.

There are 28 tone frequencies below 10 kHz using standard telegraph frequencies. Each remote station operates on an individually assigned frequency. Transmissions from the data transmitter are continuous and the status of the data receivers are updated at the completion of each correct scan. The scans from the data transmitter must follow a specific format, which contains confidence or check pulses, to allow for proper receiver operation.

The receiver stores the complete pulse train and reacts only when the confidence pulses are in the proper time segment. The number of confidence pulses varies depending upon the number of faults to be transmitted. An absence of a confidence pulse from its assigned time segment will inhibit the receiver readout and cause an error lamp to be lit.

Both data transmitter and data receiver are equipped with indicator lamps which fully indicate the status of faults in the presence of confidence pulses. Confidence stages are equipped with green lamps which indicate that the supervisory system is working satisfactorily.

Fault supervision, where continuous reporting is desired, is most effectively handled using the FA-102 supervisory system with the tone-on mode. With this mode, a data transmitter is located at each of the remote locations of a microwave system and operates on its individually assigned frequency. Each remote data transmitter can be equipped to accommodate its specific number of station data points or faults to be alarmed. The control center is equipped with an FA-102 data receiver for each remote location operating on a frequency which corresponds to the data transmitter.

All transmitters scan continuously, sending fault information to the control center. This continuous reporting features enables the control station personnel to determine at a glance the operational status of the entire microwave system.

Major alarms and change of status options can be provided so that an audible alarm can be sounded when certain selected faults from the system are reported to the control center.

Microwave repeater station at Myers, Mont.

course notify a radio maintainer for action to correct the fault. When the fault clears, the red lamp goes out and the green lamp is lighted. The buzzer again sounds, and the wire chief operates a switch to cut it off. Operation of the buzzer thus alerts the wire chief to a change of status of the alarm system without his looking.

The fuel alarm is activated when the fuel tanks at the station sites reach the ⅓ full level. For the 12 and 15 kw

Microwave equipment is completely solid state except for the

Note: It should be pointed out that the following is the manufacturer's description of his equipment. References to channel capacities are those electrically possible, but may differ as to what can be obtained under FCC rules and regulations.

Collins MW-308D, one-watt, space diversity microwave equipment operates in the 6.575 to 6.875 GHz frequency range. Completely solid state except for the one-watt klystron, the equipment features crystal controlled AFC and baseband regulations. The total available baseband could eventually accommodate 600 voice channels. At a standard repeater location, NP has, in essence, a hot standby system with two receivers and two transmitters. All are hot, but one transmitter is biased off. For spurs, such as hops reaching Laurel and Billings, only hot standby is provided. For these short hops (11.3 and 4.7 miles, respectively) space diversity is not used.

In the transmitter, baseband signals at a nominal test tone level of —33 dbm are received from the coupling or protection subsystems and applied to the modulation amplifier. The modulation amplifier has an auxiliary input for order wire and alarm insertion, or for simplified drop repeater coupling arrangements. After linear broadband amplification of up to —47 db, the signal is applied to the klystron which generates 1-watt of RF power output. The klystron is temperature stabilized by a vapor cycle cooling system requiring only distilled water as a coolant.

A small portion of the klystron output is then coupled to a precision AFC system which controls the transmitter frequency stability to ±150 kHz. This is accomplished by mixing the output of a crystal-controlled solid-state source with a sample of the RF carrier to produce a 70 MHz difference frequency. Any error in the 70-MHz signal is detected and then applied to the klystron repeller for correction of the output frequency.

Since the AFC circuitry provides a local demodulated baseband output of the transmitter, deviation can be rapidly checked or adjusted with a pilot voltmeter by setting the modulation amplifier gain to provide the same pilot level at the AFC output as at the modulation amplifier input. The transmitter branching network consists of a diode waveguide switch or a 3-cell waveguide bandpass filter, a quick disconnect flange, a waveguide shutter and a circulator. The circulator offers a low VSWR to the antenna feeder system.

Transmitter alarming includes fuse failure, 6-db drop in transmitter power, off-frequency (nominal ±0.02%), and in standby applications, a 6-db drop in pilot level at the output of the modulation amplifier.

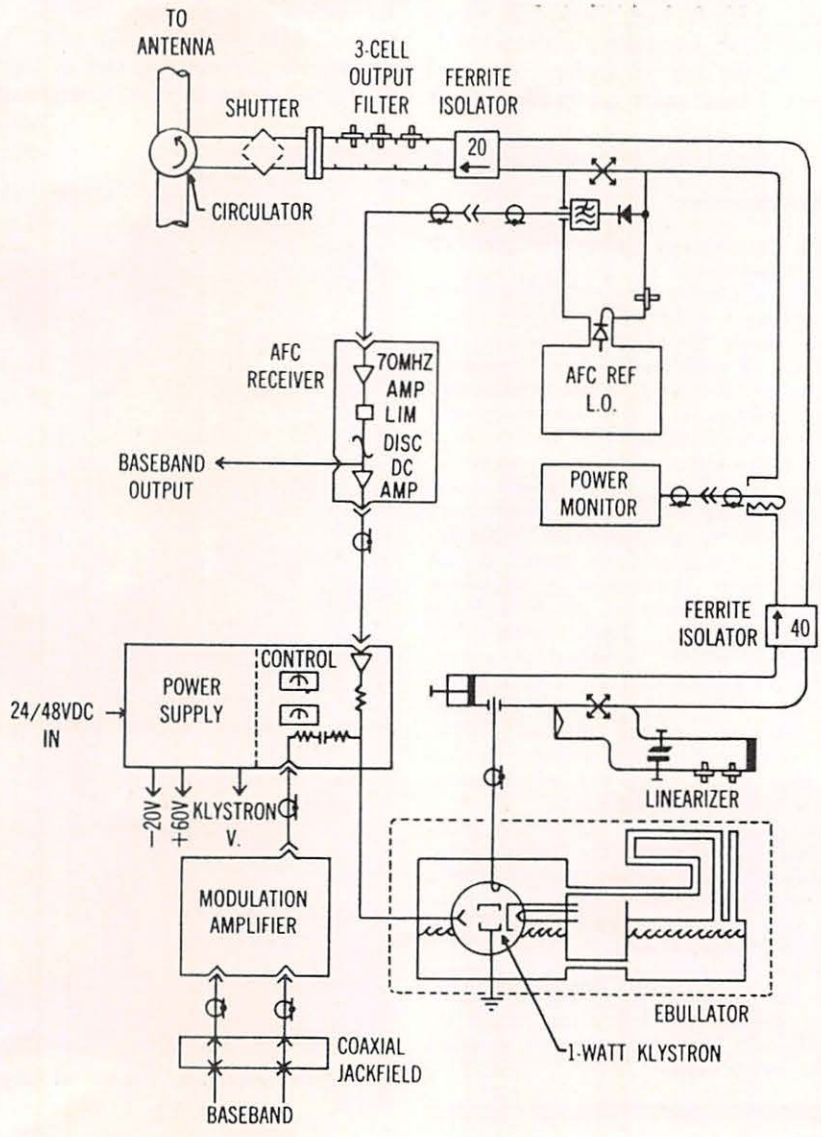
RF signals are received by the subsystem branching networks which consist of circulators, waveguide shutters, quick-disconnect flanges and 8-cell preselector waveguide filters in the receiver. In hot-standby applications, the receive signal energy is power-split into both receiver branching networks to eliminate the need for receiver switching.

The signals are down-converted to 70 MHz by means of a single-ended mixer and a solid-state local oscillator. The local oscillator is crystal-controlled for improved stability. After 30 db of amplification, the 70 MHz signal is then bandpass limited by a phase equalized IF filter. Primary amplification is provided by a broadband linear 70-MHz amplifier, which uses AGC circuitry to ensure low intermodulation noise performance and an output level variation less than 0.1 volt for a dynamic range of receive signal power of 45 db. The signal is then limited, detected by a linear discriminator, and amplified to a nominal test tone level of —33 dbm.

In space diversity and hot standby applications, receiver outputs are combined by ratio squared (maximal ratio) diversity combiners using a 3.2-MHz continuity pilot and its associated noise band. The pilot is stopped and reinserted and the noise band stopped on a per hop basis to localize and improve combining and switching. Bilateral switchover control circuitry monitors the operation of the transmitters and controls the operation of the transmitter diode switches. The protection subsystem provides noise and pilot alarms, and has integral power supplies, jackfields, built-in metering and auxiliary outputs for simple coupling arrangements and service channel/alarm drops.

NP's microwave system utilizes Collins MX-106 transistorized carrier. The MX-

MICROWAVE STATION TRANSMITTER



standby generators, 110-gallon fuel tanks are provided, but in the mountains where 30 kw generators are in service, the fuel tanks range from 1,000 to 1200 gal capacity.

For the illegal entry alarm, a magnetic switch is in the door jamb of the building.

Alarms cover the microwave system in sections and often overlap to provide read-outs in both directions. Thus,

(Text continues on page 19)

klystron tube that produces one-watt output of RF power

106, in three translating steps, can provide up to 960 fully synchronous SSB voice frequency channels following CCITT frequency recommendations for standard 4 kHz systems with options for 12- to 60-kHz subgroups.

The channel translating equipment (12 channel modems) converts 300- to 3400-Hz voice frequency information directly to the 12-channel basic group at 60 to 108 kHz. Five basic groups are translated by the group translating equipment to form the basic 312-kHz to 552-kHz supergroup. Sixteen basic supergroups are then combined by the supergroup translating equipment to form a 960-channel composite baseband signal from 60 kHz to 4028 kHz for transmission by broadband radio.

Group and supergroup translating equipments use balanced diode-lattice modulators for greater linearity over the required wider bandwidths. All active circuitry of the group, supergroup and line equipments may be furnished in parallel redundancy, thereby providing duplicated protection to all active circuitry common to more than one channel. Group, supergroup and line amplifiers when duplicated are arranged in a negative feedback configuration, such that, if one of the duplicated amplifiers should fail or be removed from the rack, the output level of the configuration will not change by more than 0.3 db. Sensing and alarm modules are available to give local alarm lamp indications and external minor (and major) alarms should the output level of either duplicated amplifier drop by more than a preset level.

At four repeater stations where drops are required, type LMX-106 multiplex is being used. Also, it provides the alarm and supervisory circuits for the microwave system. This type LMX-106 differs from the multiplex described above in that individual temperature stabilized crystal oscillators are used to generate the channel and group carriers rather than fully synchronous common frequency generation equipment. The greatest savings is where 24 channels or less are required. LMX-106 standard layouts including coupling are made available for 2-, 3-, 6-, 12- and 24-channel densities.

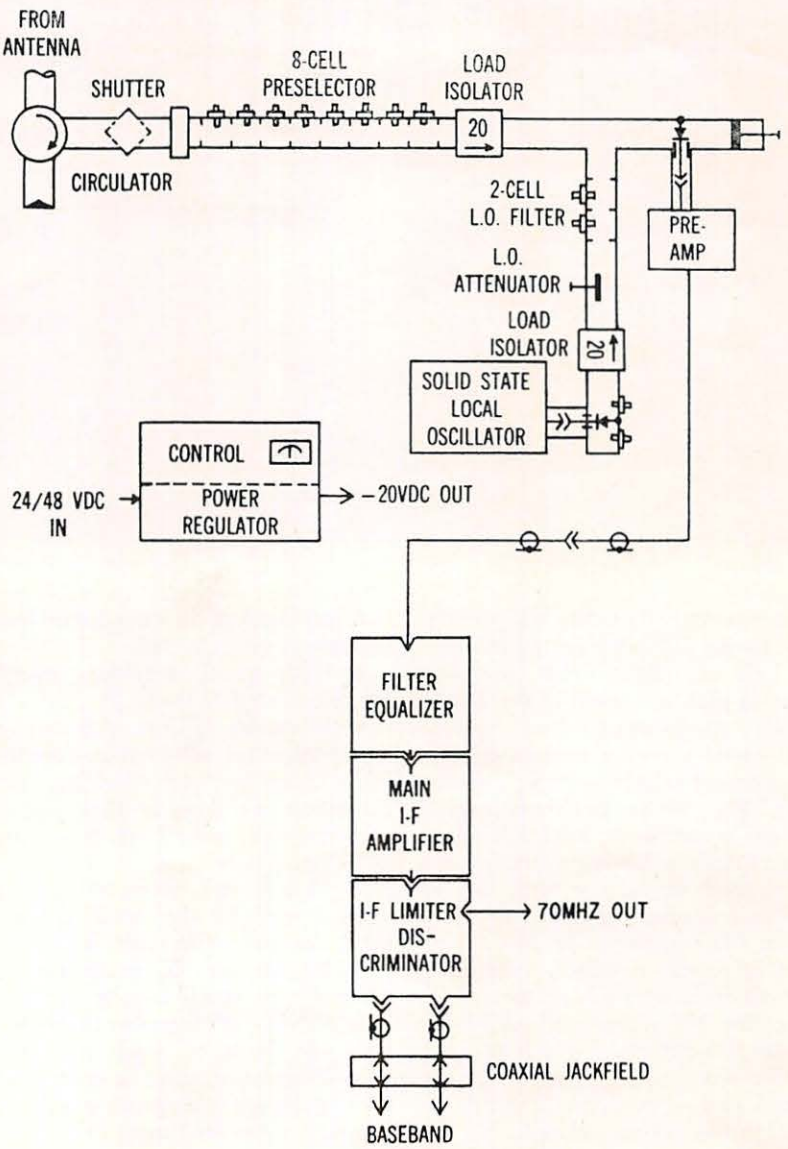
These systems use standard CCITT frequency assignments and sideband orientation between 60-108 kHz and 312-552 kHz. Up to 24 channels may be placed directly on the baseband anywhere within these line frequencies. Therefore, LMX-106 may be used at drops working into synchronized CCITT multiplex at other stations.

To meet data transmission requirements and particularly its 100 wpm teleprinter system requirements, NP is using Collins TMX-201 and Lenkurt 25B data and telegraph carrier. These are transistorized frequency shift tone multiplex carrier systems that provide for simultaneous operation of 18 data channels on a 4-wire voice frequency basis with center frequencies from 425 Hz to 3315 Hz spaced 170 Hz apart. They can provide 24 channels on a 4-wire VF basis with center frequencies from 420 to 3180 Hz spaced 120 Hz apart; or 5 channels on a 4-wire VF basis with center frequencies from 1360 to 2720 Hz spaced 340 Hz apart.

Channel spacing of 170 Hz provides for 100 wpm operation (80 baud) with a maximum total distortion of 5% in any channel throughout the entire range of rated operating conditions. The frequency shift normally used with the 170 Hz spaced channels is ±42.5 Hz. Similarly, 120 Hz spaced channels are designed for 66 wpm operation (50 baud) with a total distortion of less than 5%. The frequency shift for the 120 Hz spaced channels is ±30 Hz. Midband channels in either system exhibit still lower distortions of typically 3%.

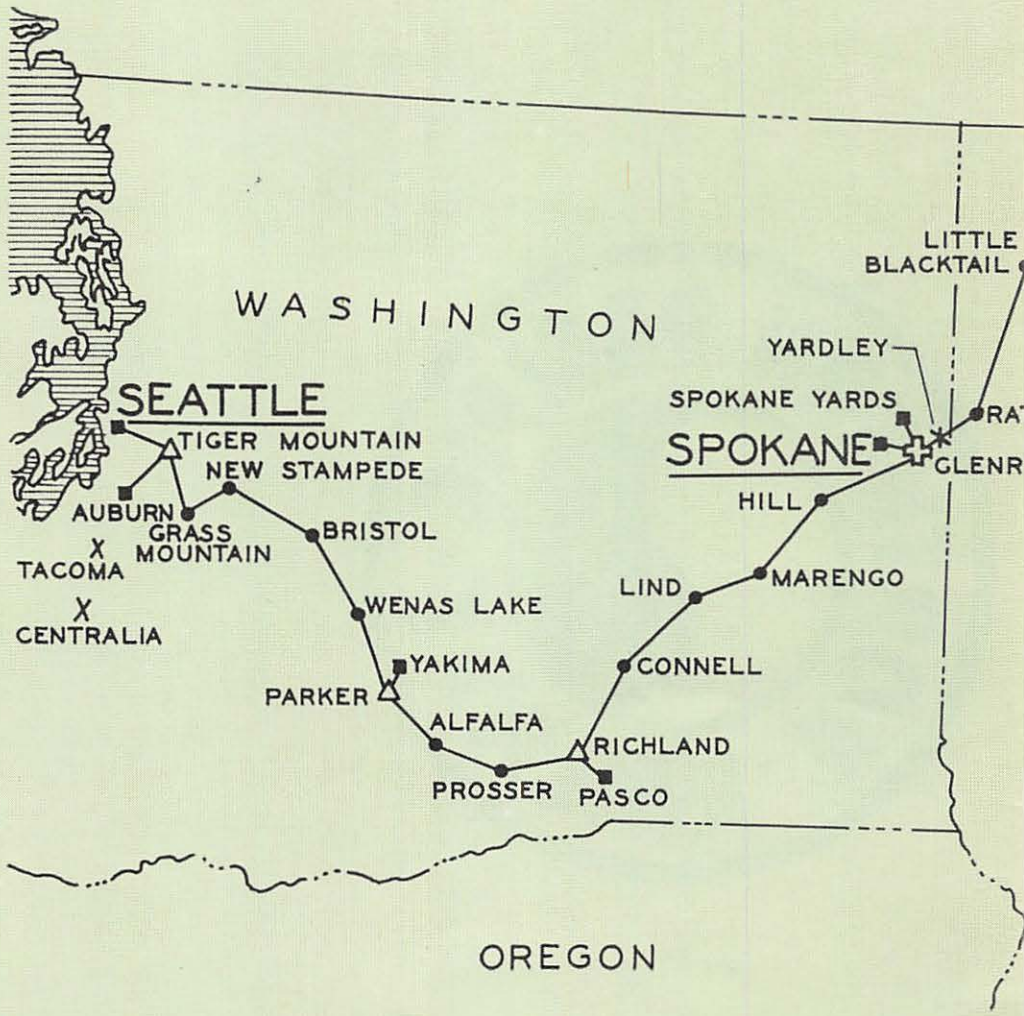
Transmitter employs frequency shift keying techniques to convert binary data to mark and space tone frequencies for transmission at channel levels as high as 0 dbm without requiring transmit line amplifiers. Receivers with a 40 db dynamic range accept the audio tones at levels as low as —40dbm, and reconvert these inputs back to binary informatiion. Either low frequency or high frequency marking may be used, and these conditions may be simply reversed by integral switches located on the transmitter and receiver cards. All transmit filters in the TMX-201 system have the same insertion loss (within ±1 db) regardless of center frequency used in the system.

MICROWAVE STATION RECEIVER



Communications Facilities Map

Lift up



(Continued from page 17)
there is a type of backup system. For example, Fargo gets alarm readouts to St. Paul and to Rimrock, near Billings. St. Paul also reads alarms to Fargo. And Glendive, about midway between Fargo and Billings, gets alarm readouts to both Fargo and Billings.

In superintendent of communications Hill's office is a 10 ft by 4.5 ft fault alarm display map showing the entire microwave system, the NP mainline and time zones. Each microwave station is represented by two lights: a red one to indicate a fault; and a green one to indicate that the station is operating satisfactorily.

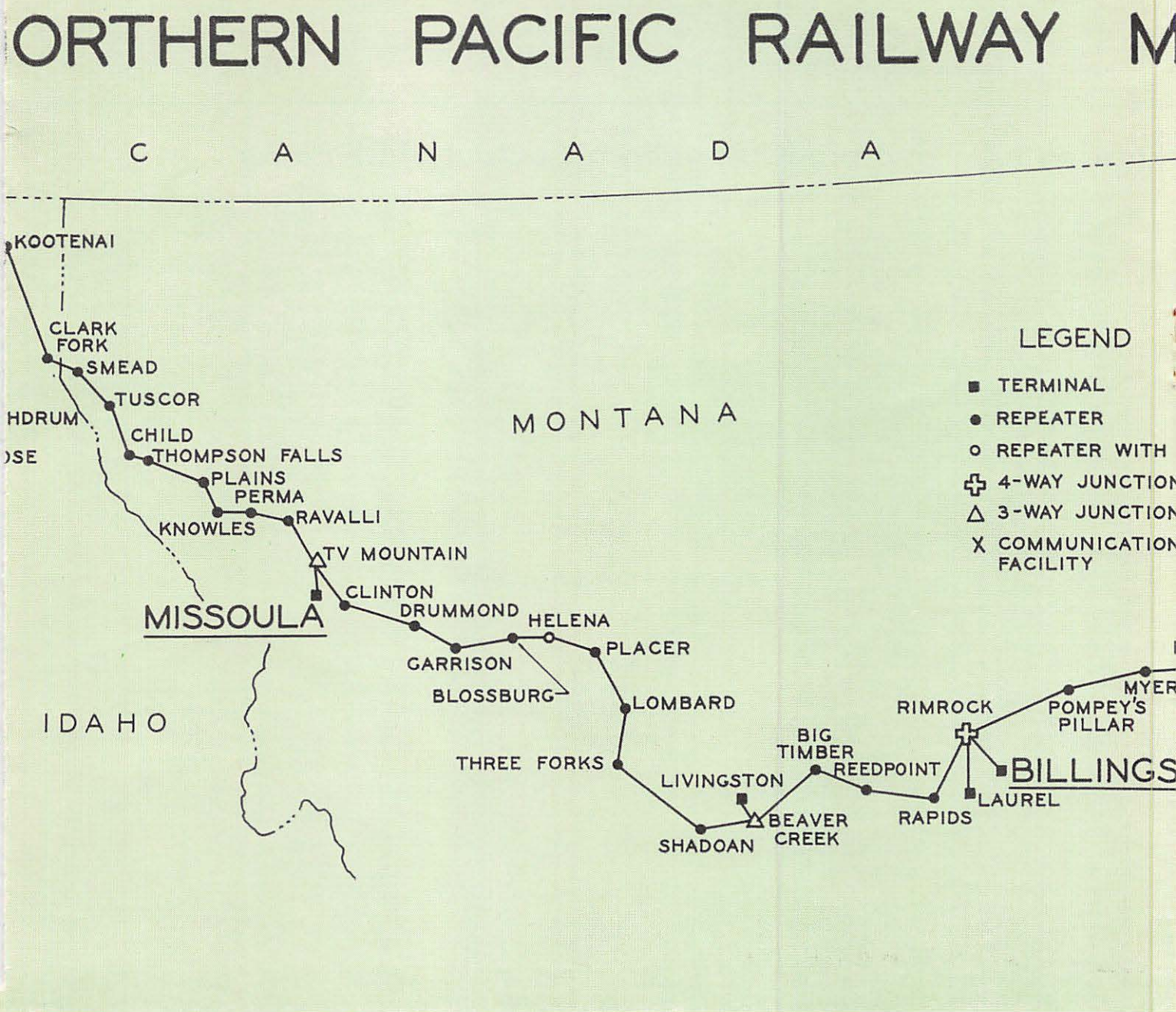
The information required for operation of this display map in Hill's office in St. Paul is acquired from the basic FA-102 (tone on) fault alarm system. The basic FA-102 system is used to activate a secondary FA-102 fault alarm and voice channel system which transmits the station alarms to St. Paul.

Hill points out that this map display has proved very valuable and time saving for him. Particularly is this helpful when someone has trouble making a phone call or a teleprinter circuit fails. If the caller is "big brass upstairs", it is helpful for Hill to know the status of the microwave system.

Although Collins installed the microwave system, NP intends to maintain and service the equipment. As part of the contract, Collins trained NP radio maintainers, some supervisors and some wire chiefs in the operations and maintenance of the equipment. These men having an FCC second class or first class radio-telephone license attended two weeks of classes at Collins' Dallas, Texas plant. One week was spent on the RF equipment and a second week on the multiplex systems. By the time the microwave system is operational, NP will have sent 35-40 men to the Collins school.

These radio maintainers, as their titles indicate, will be responsible for 7-8 microwave stations as well as several VHF radio base stations. Microwave stations are inspected quarterly and system line-ups are made at these three-month intervals. Presently, NP is obtaining about 9,000 hours life on klystrons, which amounts to a little over 12 months.

One of the big advantages for NP



telephone users is that they will shortly be able to dial any office on the railroad using only six digits. This universal numbering plan is a result of the road's installing Stromberg-Carlson motorswitch 4-wire common control switching equipment which includes register senders. The 4-wire switching equipments are located at St. Paul, Glendive, Billings, Missoula, Spokane and Seattle.

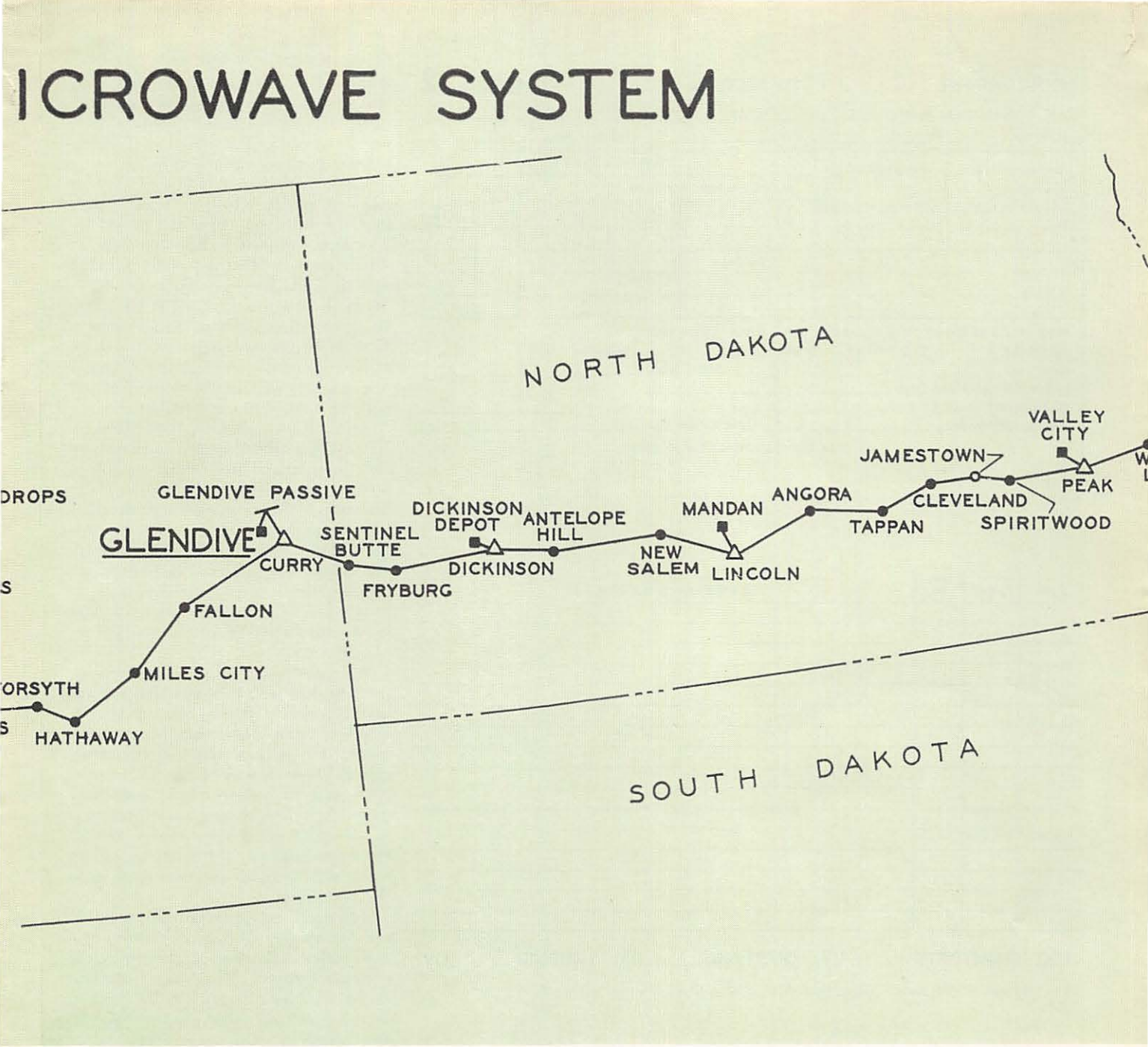
NP gained experience with 4-wire switching equipment when it installed the first S-C equipment in 1957. This system, however, switched only eight carrier channels at each of the six locations. The NP motorswitch system is wired for 800 circuits of which 532 will be in use when the system is fully operational early next year. Future expansion can be accommodated.

Advantages of the new 4-wire motorswitching system include:

- High speed switching capability for voice and data traffic.
- Minimum end-to-end transmission loss with attendant high uniformity of transmission level for all calls, whether extending over long or short distances and through several or few tandem switching points.
- Motorswitch 4-wire switching provides 4 wires for the audio path and 4 wires for call supervision and control.
- Register-sender equipment provides for universal numbering. In the case of NP, the subscriber needs to dial only six digits to reach any station.
- Alternate routing is controlled by the equipment to improve service when primary routes are busy.

NP is also upgrading other telephone facilities. For example, by the end of next year all stations on the mainline will be equipped with dial telephone service. Most of the message circuit dialing equipment is being replaced with PABX dialing and a new S-C developed dial line adaptor which can accommodate up to 10 stations on a line. This equipment upgrades service by reducing the numbers of stations on a line.

At Staples, Jamestown, Mandan, Dickinson and Helena, NP installed 100-line, Stromberg-Carlson Compak switching equipment. These smaller exchanges have the ability to handle calls on a universal numbering basis, and frequency selective ringing to handle multi-party message dialing systems.



At present, NP has nine attended, leased PBXs, but has plans for converting some of them to automatic exchanges.

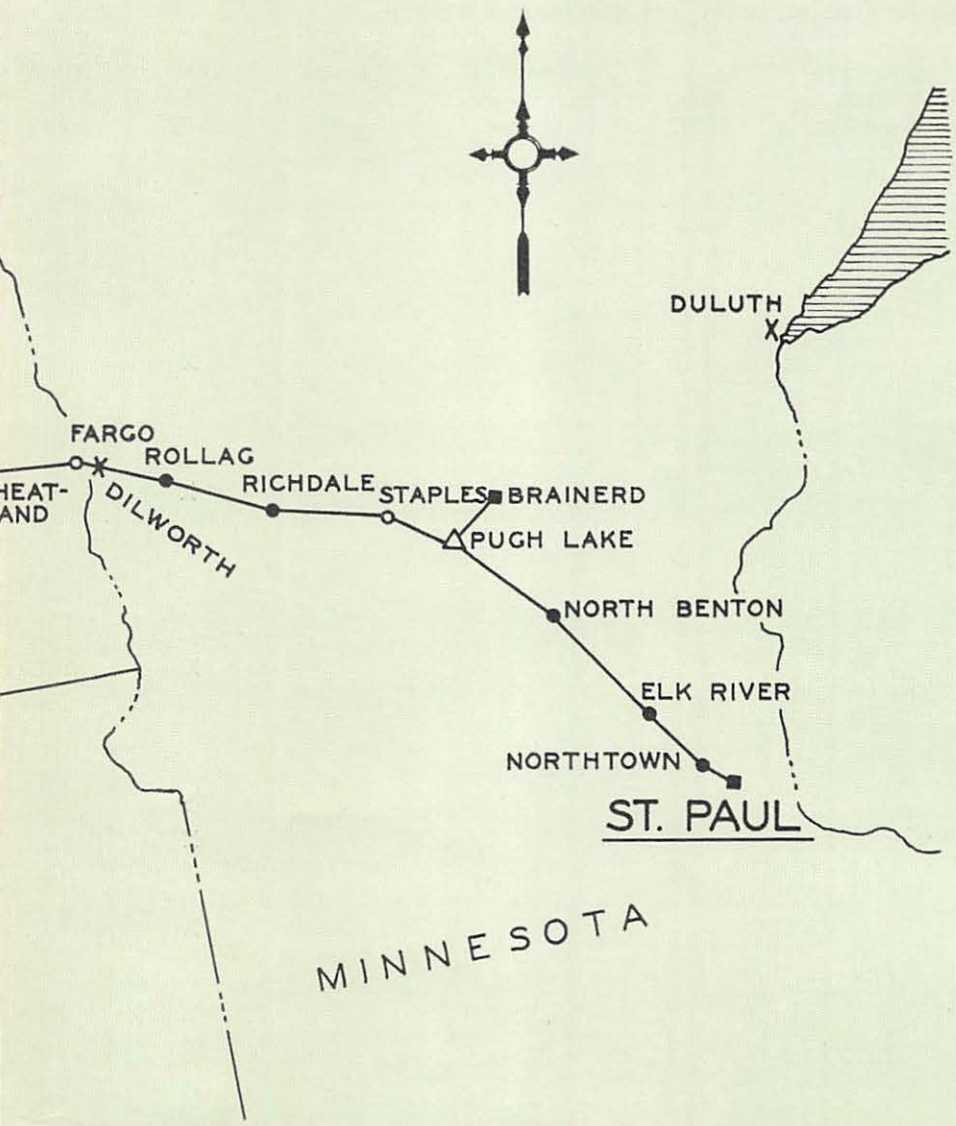
NP has telephone maintainers at 11 points on-line and one teletypewriter maintainer. These maintainers have at least a second class FCC radio-telephone license.

For the future, NP is considering two possibilities as extensions of its 4-wire switching capability: handling data transmission and mobile telephone service. Although not now in service, the 4-wire switching equipment is capable of handling data transmission on a switched basis. This might be feasible at night when telephone traffic is lowest. With extensive use of subscriber tone dialing, NP could provide mobile dial telephone service to its vehicles. Such might be most helpful to trainmasters, communications maintenance personnel and M/W crews that often have to be away from telephones. Although many are now equipped with two-way radio, the mobile dial service would enable them to be connected into NP's dial telephone system, giving them ready access to any railroad office.

As might be expected from the size of its communications plant, NP considers maintenance of this plant to be an important function. In addition to manufacturers' training of men on microwave and 4-wire switching equipments, Motorola conducted classes for NP radio maintainers to acquaint them with servicing of its Motran solid-state, two-way radio equipment line.

NP has 15 microwave and radio shops which are spaced approximately every 100-200 miles across the system from Duluth to Seattle. Similarly, telephone maintenance points (location of a shop or headquarters of a maintainer without a shop) are spread across the system. Additionally, teletypewriter maintainers are located at Spokane, as well as at the communications shops located at St. Paul and Seattle. These shops serve for general repair and servicing of telephone, teletypewriter and carrier equipment.

NP telephone maintainers have 20 automatic exchanges, six 4-wire switching equipment centers, dial telephones over most of the system as well as party-line dialing equipment to ser-



vice and maintain. On the teleprinter side, NP has some 40 yards and offices equipped with this communications equipment, which also has to be maintained and serviced.

NP was one of the pioneering roads in the use of radio. Hill, then under F. L. Steinbright, worked on the first installation of the road's dispatcher-to-train wayside radio system in 1952. This 410-mile system between Dilworth, Minn. and Glendive, Mont., has since been expanded to cover about 1170 miles from Fargo to Spokane, with the exception of a 70-mile section from Missoula to Paradise, Mont. Where CTC machines are located at Glendive, Missoula, Spokane and Tacoma the dispatcher has control of wayside radio stations in CTC territory enabling him to contact or be contacted directly by train crews.

In all, NP has some 136 radio base stations for the railway and 4 for NP Transport Co., its trucking subsidiary. Mobile transmitters total 1,400, and the road has about 300 walkie-talkies.

Mechanical department employees change radio sets on rolling stock and radio maintainers take care of the base stations. NP has standardized on 30 watt sets for locomotives (64 volts DC), cabooses (12 volts DC), and base stations (117 volts AC). Automotive-type radio equipment is used in trucks, automobiles and on M/W equipment, operating on 12 volts DC. Consideration is being given to provide some automobiles with mobile dial phone service working through base radio stations.

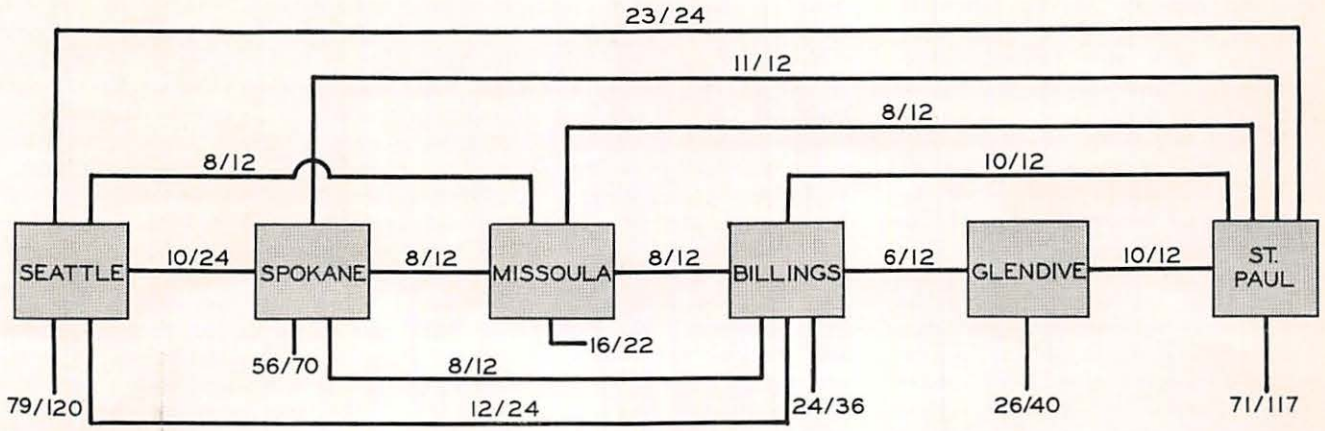
In a few locations where the railroad line is in a canyon or heavily wooded area, repeater stations have been installed to provide improved radio coverage. These repeater stations are keyed by adjacent wayside base stations. The repeater station is located so as to be able to beam its signal to the area normally missed by the other wayside base stations.

Most radio maintainers have ¾ ton pickup trucks, but as these trucks are replaced the maintainer is provided with a ¾ ton unit with a walk-in van. If the radio maintainer has microwave stations in his territory, he is probably equipped with a 4-wheel-drive truck with a winch. In the Cascade mountain

(Text continues on page 24)

NP Communications Facility and Maintenance Points

Location	Microwave alarm readout	Microwave & radio shop	Wire Chief	Telephone maintainer location	4-wire switching center	IBM 1050 unit	IBM 2780 unit
Duluth		X		X		X	X
St. Paul	X		X	X	X	X	
Brainerd		X		X		X	
Northtown yd		X				X	X
Staples						X	
Dilworth		X				X	
Fargo	X		X	X			
Jamestown yd				X		X	
Mandan		X		X		X	
Glendive	X	X	X	X	X		
Billings	X	X		X	X	X	
Laurel yd						X	X
Livingston	X	X	X	X			
Missoula	X	X	X	X	X		
Missoula yd						X	X
Yardley						X	X
Spokane	X	X	X	X	X		
Pasco yd						X	X
Pasco		X		X			
Yakima		X		X		X	
Auburn yd		X				X	X
Seattle	X	X	X	X	X	X	X
Tacoma				X		X	
Centralia		X		X		X	



Direct circuits connect NP's motorswitch 4-wire switching centers. Digits to the left of the slash represent the number of equipped circuits now being switched. Digits to the right of the slash indicate the number of wired circuits that can be equipped for 4-wire switching.

GOVERNMENT INSPECTION RECORD 2

F. C. C. MEASUREMENT MADE: _____, 19____ AT _____

N. P. NO._____ MFG._____ TYPE_____ SERIAL NO._____

FREQUENCY - MC.		DEVIATION - KC.		POWER - WATTS							
				MANUFACTURER'S MAXIMUM				MEASURED			
ASSIGNED	MEASURED	ASSIGNED	MEASURED	EP x IP = PIN			RATED OUTPUT	EP x IP = PIN			BIRD OUTPUT

FREQUENCY AND DEVIATION MEASUREMENT MADE WITH (CHECK ONE)
MOTOROLA, ( ) DOOLITTLE ( ) OR_____MONITOR
MODEL NO._____ SERIAL NO._____
LATEST RECALIBRATION DATE:_____
MEASUREMENT MADE BY:_____
F. C. C. LICENSE NO._____ EXPIRATION DATE:_____
(RETAIN THIS SECTION AT RADIO SHOP)

Front face of the 4-part radio inspection card is identical for all parts.

DATE	HOURS	STAGE NO.	REPAIR ANALYSIS

REC. SENSITIVITY_____UV, QUIETING_____DB, SQUELCH_____UV

Rear portion of the radio inspection card is also the same for all parts.

RADIO TRANSFER RECORD	RADIO TRANSFER RECORD
N. P. RADIO UNIT NO._____	N. P. RADIO UNIT NO._____
PLACED IN SERVICE ON	PLACED IN SERVICE ON
DIESEL NO._____	DIESEL NO._____
CABOOSE NO._____ OR	CABOOSE NO._____ OR
BASE STATION AT_____	BASE STATION AT_____
ON (MO.)_____ (DAY)_____ (YR.)_____	ON (MO.)_____ (DAY)_____ (YR.)_____
REPLACING N. P. UNIT NO._____	REPLACING N. P. UNIT NO._____
(RETAIN THIS SECTION AT RADIO SHOP)	(MAIL THIS SECTION TO SUPT. OF COMMUNICATIONS)

FORM NO. NP 1043

When a radio set is placed in service, this record form is properly filled out to aid in locating the set.

(Text continued from page 22)

areas, NP has some Thiokol snow cats that can carry six men, and some one-man Skidoes which are motor-driven units and can pull a toboggan if necessary for carrying equipment.

When a radio set is brought into a radio shop, for whatever reason, it is given a full and complete check for operation, frequency, deviation, etc. A 4-part card is filled out; part 1 being sent to C. A. Bacon, radio engineer, in St. Paul; part 2 is retained at the radio shop; part 3 is for base stations and is filed in a plastic holder at the base station location (which holds about a one year supply of these cards); and part 4 is tagged to the radio set.

At St. Paul, part 1 cards are filed by NP number. Periodically, a summary sheet is prepared from these cards and sent to the men in the field. These list some of the more common recurrent failures, and some of the most successful repair analyses. These summary sheets and the analyses undertaken to prepare them often provide clues as to what types of components are failing most and should be considered for replacement.

Also, the men in the field receive periodic lists of radio sets due for annual frequency checks. Sets are usually listed in three groupings: those having gone 10 months without a frequency check, those having gone 11 months without a frequency check, and those past due. These lists are also distributed to the mechanical department so that their men can spot these sets on rolling stock, pull them off and turn them in to the radio shop.

The radio maintainers make monthly checks of the dispatcher-control systems that provide train-to-wayside communications. The base stations under such controls are usually checked at this time, including an inspection of the antennas. One radio maintainer usually covers 7-8 microwave stations plus the radio base stations in the same area. However, the microwave stations have priority for his time and attention.

To keep the radio engineer's office advised as to the location of radio sets, a two-part radio transfer record card is filled out when the maintainer or a mechanical department employee installs a radio unit. One portion is kept at the radio shop and the stub is mailed to St. Paul. From these stubs, filed in NP radio unit number sequence, the frequency check list can often pinpoint the location of the radio unit on a locomotive, caboose, automobile, truck, or at a particular base station, or if a walkie-talkie the station or yard office or person to which it is assigned.

An interesting radio system usage is at Duluth-Superior where the NP crosses two channels into the Port of

Duluth via a Wisconsin drawbridge and a Minnesota drawbridge. Also using this double-track line is the C&NW, GN and MILW. Each bridge tender has two radio base stations: one to operate on each of the four railroad frequencies and one to operate on two frequencies for talking to the Port of Duluth and to boats that pass through the channels. Boats have the right-of-way over trains. Although whistle signals are used between bridge tenders and the boats, they also communicate via radio.

A monitoring system continuously scans the four railroad radio channels at the rate of one each second. When a call, say from a train, is originated on one of these channels, the bridge tender's receiver equipment locks on that channel and he hears the call. After the call is completed, a lamp is lighted to alert him that there was a call on that particular channel. Thus, if he was busy at the time of the call, he can initiate a call on that channel to find out if he was wanted.

Much of the credit for the success of NP's communication department in bringing the railroad into a position of being able to efficiently handle the increased communications traffic load is due to Don Hill's "hand-picked" communications staff. No small part of this success is due to an esprit de corps that the whole department is working as a team to provide the finest for the NP.

Another part of the success is no doubt due to the specialization that Hill has fostered in his department. He will readily admit that with today's expanding and rapid change in technology one man cannot keep fully abreast of developments in all areas of communications. Hence, the specialist is necessary and plays an important role.

Hill's present team consists of Fred B. Childs, assistant superintendent of communications at St. Paul, heading up the eastern half of the railroad's communications plant and Gordon F. Hill, assistant superintendent of communications at Seattle, Wash., holding a similar function.

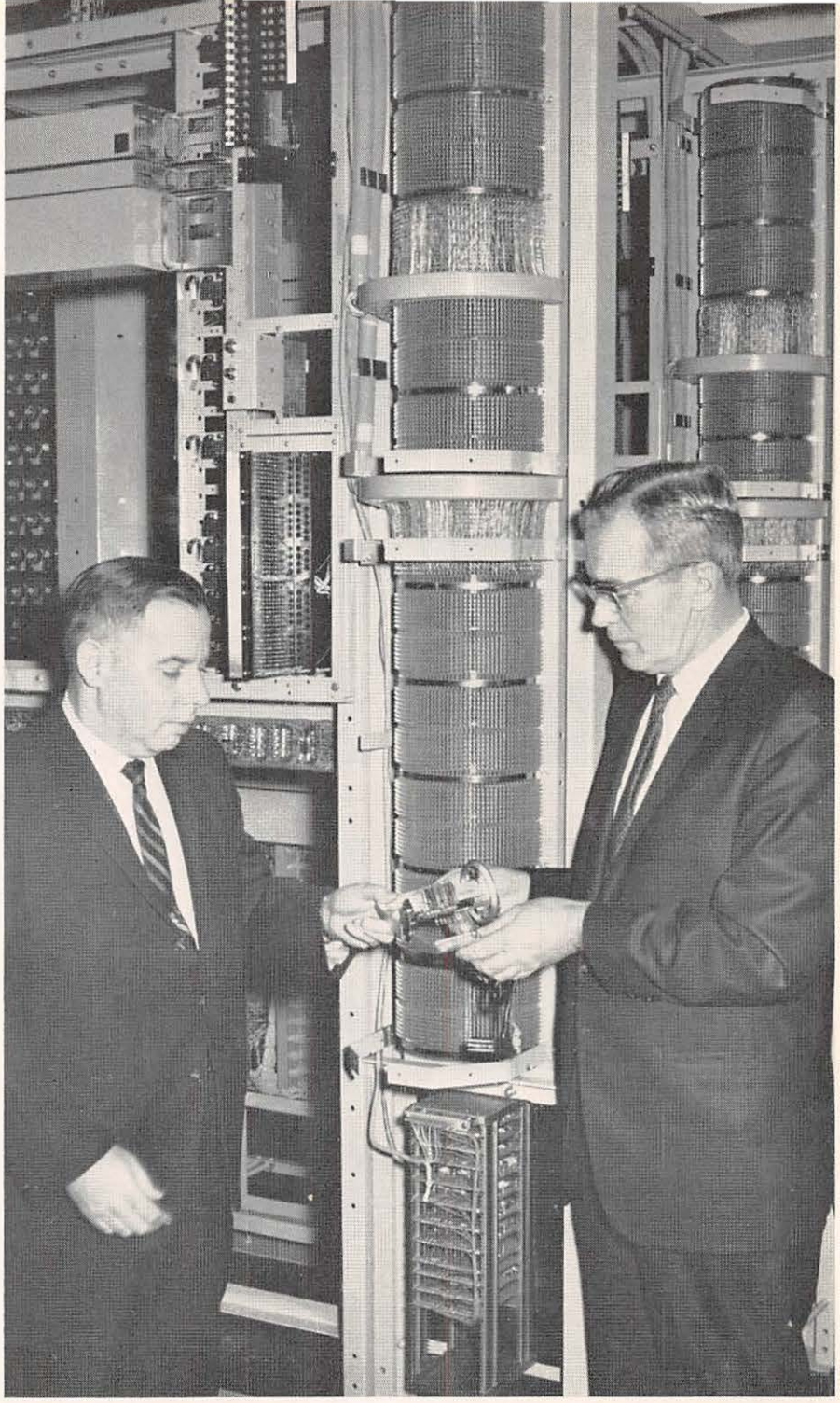
Leonard L. Pilate, manager data communications systems, is the data communications specialist, with the exacting job of forecasting needs to meet Frank Coyne's expanding management information services department. Much of Pilate's work is concerned with channels and equipment such as teletypewriter facilities, and the various IBM card transmission units. He is aided by Hugh E. Morrison, assistant manager and D. B. Goodwin, traffic supervisor.

Telephone engineer Kenneth M. Rue and three assistant telephone engineers L. J. Grivna, J. L. Petersen and M. R. Timm are, of course, concerned with NP's system-wide dial telephone system. They do planning, design and supervise installation work in this area.

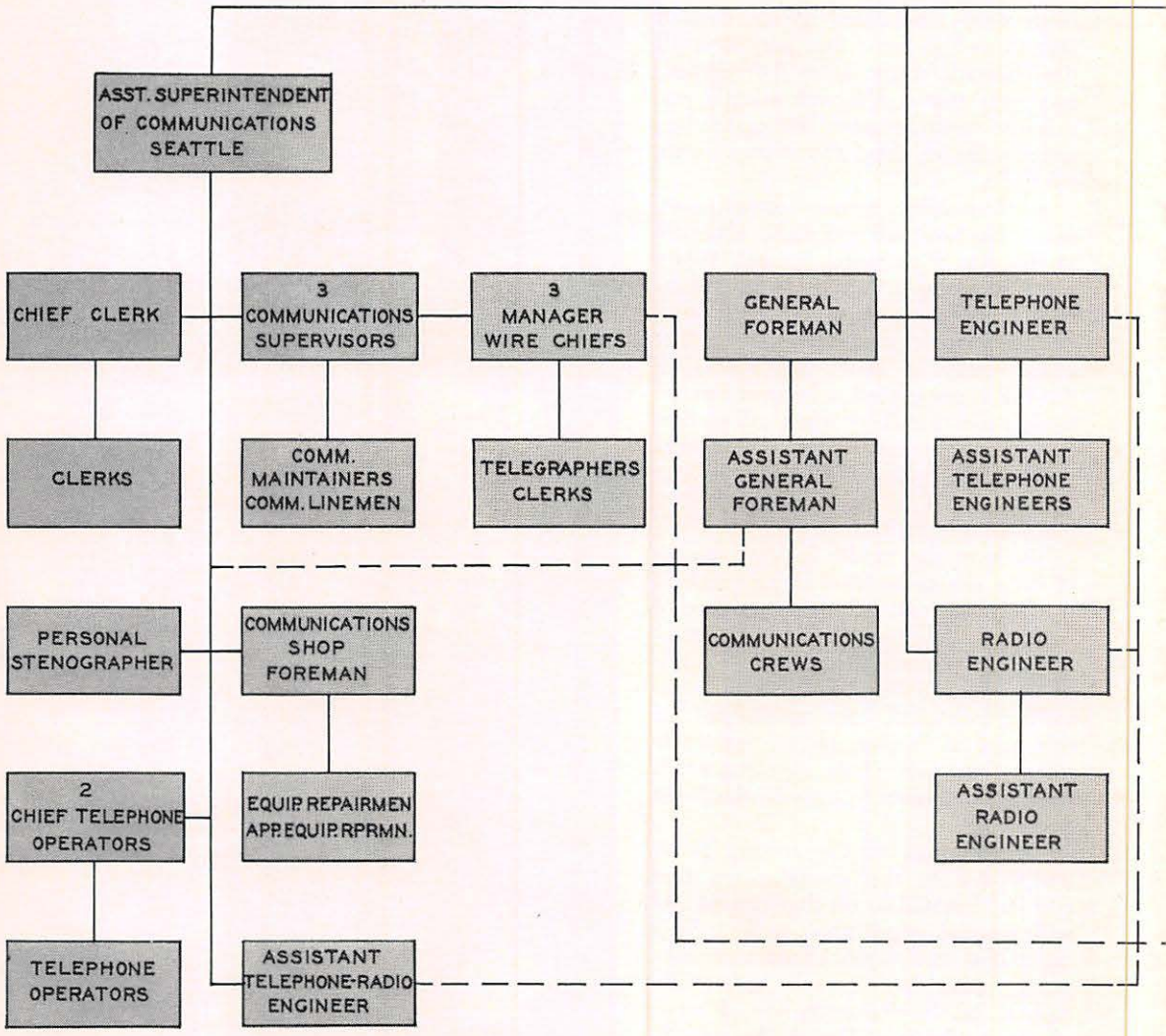
Radio engineer Chester A. Bacon and assistant radio engineer G. E. Nelson are concerned with radio and microwave. Here too, they do planning, design and supervise installation work.

Since Pilate, Rue and Bacon are always looking for more communications channels, it is natural that they coordinate their tasks with Don Hill and his two associates Fred Childs and Gordon Hill. As there is a limit to funds available, and microwave and physical circuits available, there has to be a blending and balancing to come up with the most efficient mix for the total communications needs of the railroad.

One of Don Hill's philosophies, if you wish to give it that sophisticated name, is that communications, unfortunately, is not obvious, and that it must be sold by good example. For example, Hill sold NP management on the concept of installing microwave between Portland, Ore. and Seattle,



Fred Childs (left) and Don Hill examine motorswitch used in 4-wire switching system.



Wash., in 1962. Because of limited funds, this Motorola system had no standby power plants and no space diversity. However, it has been working satisfactorily since that time. Immediate savings of $80,000 were realized by the removal of 35 miles of pole line. Also, the microwave provided enough circuits so that an automatic dial telephone exchange could be installed at Tacoma with the resultant annual savings of $40,000 in salaries and equipment rental. Performance of this Portland-Seattle microwave system did much to help Hill show management what microwave could do for the NP.

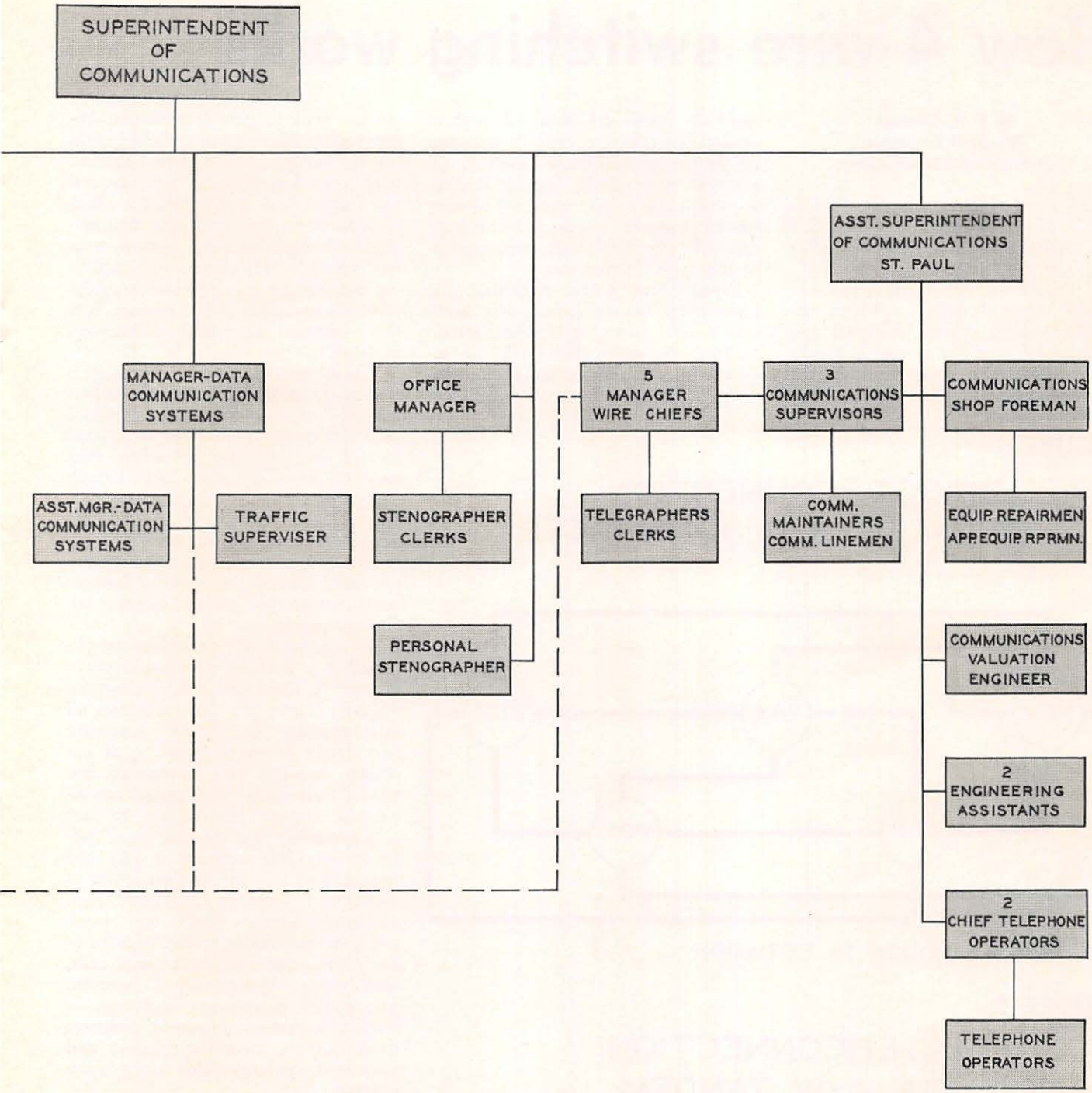
Hill believes in follow up, that is, once a proposal has been properly prepared and the concept sold to management and the system installed, it is important to report back to management on the performance of the system and give efficiency or savings figures, if possible.

Communications is a service organization, says Hill, and as such it is well for the communications man to get around the railroad, visiting and "getting to know" the various department heads.

Many of the maintainers and installers on NP communications department have taken the road's home study electronics course or have taken correspondence school courses to obtain their FCC radio-telephone licenses. With tuition refund plans, plus encouragement via promotions for technically trained men, Hill finds himself in the happy position of not losing any men to outside industry once they were trained for their NP work.

While most of the department's work is concerned with communications, once in a while Hill and his men tackle problems that are on the fringe of their work area or outside of it. "But," says Hill, "since we're the electronics experts, we sometimes get involved."

One such fringe area work has paid off handsomely for NP. It is a diesel



warning system to prevent the water in the engine cooling system from freezing. On some branch lines, where engines tie up over the weekends in winter, the temperature will fall to 30 or 40 deg below zero F. In 1966, the diesel warning system saved NP about $277,700 through the elimination of 58 engine watchmen positions, and saved $78,000 in diesel fuel.

The diesel warning system was in operation at 27 locations and had 120 outlets available for connections to diesels. Electrical connections are made from the heater in the water jacket of the diesel to an AC source and to a telephone line after the locomotive is shut down for the night or weekend. The water temperature should be kept above 150 deg. F, but if it falls below 100 deg. F, then an alarm bell rings in a section house or depot where someone is on duty. Then a man, usually a hostler, is called to start the diesel and run it for 30 minutes to heat the water.

Before such diesel warning systems were in service, men were employed as watchers to check the temperature of the water periodically. If it was low, they would start the diesel or call a hostler. Also, some engines were kept in heated buildings. As a result of installing the diesel warning systems, the heated buildings are no longer required as are the several watchmen's positions. This diesel warning system was the result of cooperation with the mechanical department upon their request to Hill as to what could be done about the freezing problem.

In summary, NP communications is in its present advanced state and readiness to efficiently handle today's and tomorrows voice and data traffic because of the organization that Don Hill has created and molded over the years with men working together and with others toward a common goal, namely the best communications service possible for the Northern Pacific.

How 4-wire switching works

By E. H. Gatzert,
Principal Engineer,
Stromberg-Carlson Corp.

This is an abstract of a paper presented at the Communication & Signal Section, AAR, annual meeting in Dallas, Tex., Oct. 1-3, 1968.

This paper describes a 4-wire tandem switching system designed specifically for privately owned networks. The major design objectives were: (1) a reliable transmission path, suitable for both voice and data, (2) register sender operation to permit universal numbering and alternate routing, (3) a system economically feasible in sizes as small as 20 to 30 trunks, (4) offering special features required by private users, (5) compatible with existing step-by-step type 4-wire offices.

Private user 4-wire switching first came upon the scene in a very small way in 1957 when the Northern Pacific realized the gains that could be attained by establishing six 4-wire tandem switching centers. The primary purpose was to gain transmission improvement. This system switched eight carrier channels at each of six locations. It performed its expected functions and was helpful in demonstrating the efficacy of 4-wire switching in industrial networks. Today this same system, now engineered for 800 circuits and employing common control motorswitch equipment serves a total of 532 circuits. It is this equipment which will be described in detail.

FIGURE 1

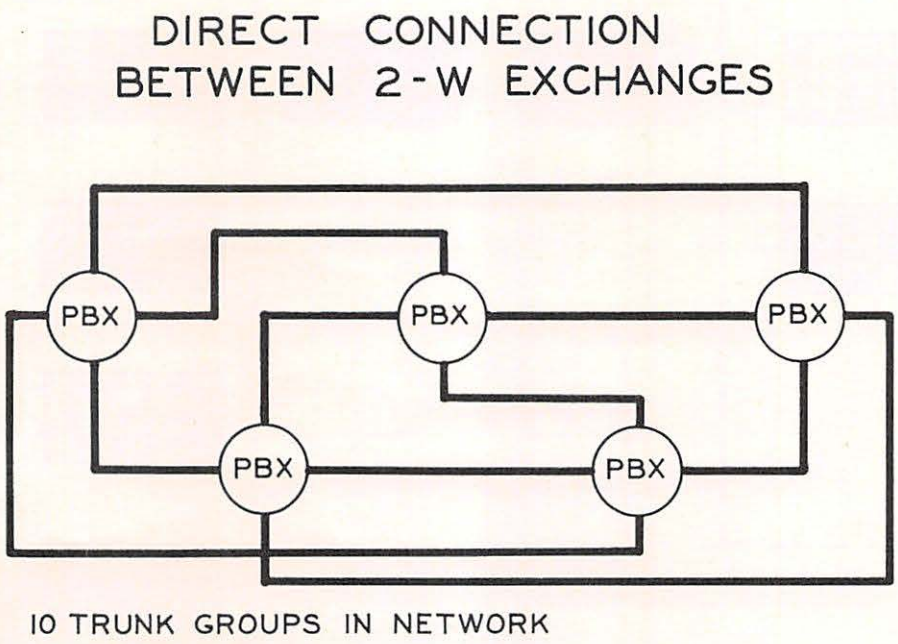
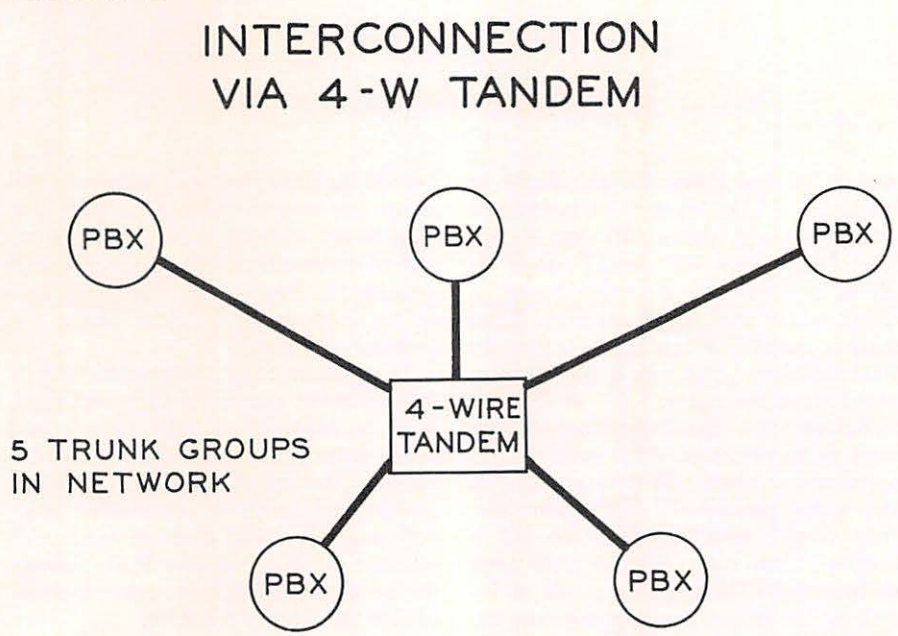


FIGURE 2

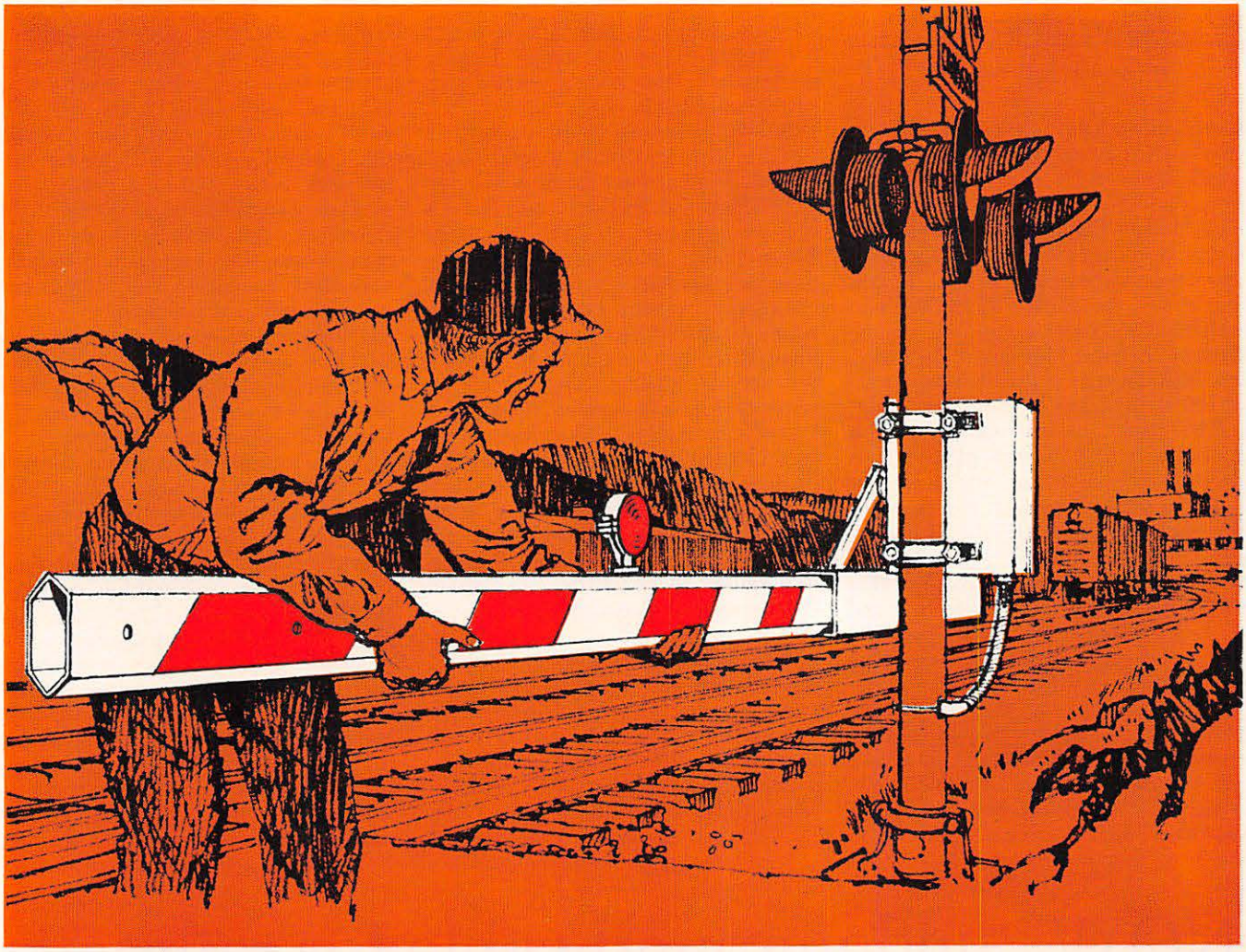


The advantage of 4-wire switching is the achievement of minimum end-to-end transmission loss with attendant high uniformity of transmission level for all calls, whether extending over long or short distances and through several or few tandem switching points. If the 4-wire switch utilizes register senders then, of course, universal numbering and automatic alternate routing are also achieved; and optional features such as restriction and pre-emption become available.

An additional advantage can be obtained in a network where microwave is used to interconnect all exchanges. Figure 1 shows five dial exchanges all interconnected by trunks. Assuming five trunks in each group, each exchange requires four groups of five trunks. Such small trunk groups are inefficient, carrying only about 46 unit calls per group; and the total trunk traffic for any one exchange is only 184 unit calls. If a 4-wire tandem center as shown in Figure 2 is established, each exchange requires only one trunk group to carry all the traffic. In order to carry the same number of unit calls, each group requires only 11 circuits, saving nine circuits per exchange. In terms of microwave channels, exchange trunk circuits, incoming selectors and associated equipment, this saving is significant.

The requirements of private user networks are somewhat different than those of the common carrier network since they are perforce configured frequently to coincide with the special geographical environments. In the public network, switching centers are arranged in an hierarchical manner, geographical location being only one of many factors. The organization of a private network is determined primarily by demands imposed by geographical layout of the system and available transmission facilities. Thus, railroad and pipeline organizations generally use a network arrangement such as shown in Figure 3 which represents a grid-type arrangement. Public utilities,

(Please turn to page 30)



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Circle 13 on reader service card on page 38

(Continued from page 28)

on the other hand, serve a specific region with a communications center located at one point. This is best served by a hub-type network arrangement illustrated in Figure 4. This latter type of trunking arrangement is by no means restricted to utilities. It is used, for example, by the Kansas City Southern which has one large 4-wire motorswitch tandem center at Shreveport, La., serving 30 exchanges and switching a total of 100 circuits.

The choice of network as well as special user requirements place certain demands on the system which are not found in public networks. For example, the need for automatic alternate routing upon encountering a busy condition at a remote point may require that the partial connection be released and a second attempt be made from the originating office. A typical example of this is shown in Figure 5. The call enters the tandem network at A and the primary route requires that the call be switched at C to E. If the C-E trunks are busy, the assigned alternate route, switching through B and D requires that the call be released forward in order to permit selection of a different path out of A. This type of operation requires register sender features not available in common carrier type switching systems.

Another unusual arrangement is based on the desirability of retaining 7-digit dialing encountered in public networks. However, in this system the register sender is not in the PBX but in the 4-wire tandem. Thus the first subscriber dialed digit is required to route the call out of the two-wire exchange into the 4-wire tandem. For this reason a maximum of six digits are actually available for network dialing. Four digits are required for calls terminating in large two-wire exchanges. This leaves only two digits for translation to provide the functions of area and office codes. It is these two digits, unique to a given destination, which can provide the basis for the sender-generated routing digits required to switch the call through the network and into the terminating office.

In addition to these special requirements, office size variations impose certain demands. In order to satisfy user requirements, it was deemed necessary to provide a system which would be economically justifiable when switching relatively few circuits. On the other hand the system must be capable of accommodating growth without penalties. It was felt that floor space requirements were of major importance. These and other criteria such as compatibility with exisiting step-by-step 4-wire systems were examined in detail and became the basis of the design plan for the motorswitch 4-wire switching system. The proposed approach was reviewed by communications personnel from several major roads who were potential users and their comments and suggestions were incorporated into the plan.

Thus the 4-wire motorswitch system which is in operation at the present time in a number of locations has been developed through a joint effort on the part of the manufacturer and users.

The 4-wire switching system employs the motorswitch. It is a plug-in high speed single motion switch having 112 bank outlets. The switch has two sets of eight wipers each, four for carrying the transmission path and four available for control purposes. The contacts of the wipers and the mating bank employ precious metal for the transmission path. The transmission wipers do not touch the bank until the switch has been positioned. Because the switch has a sufficient number of wipers to isolate the control functions from the transmission path and the transmission path is switched with precious metal contacts, it has been possible to design the sys-

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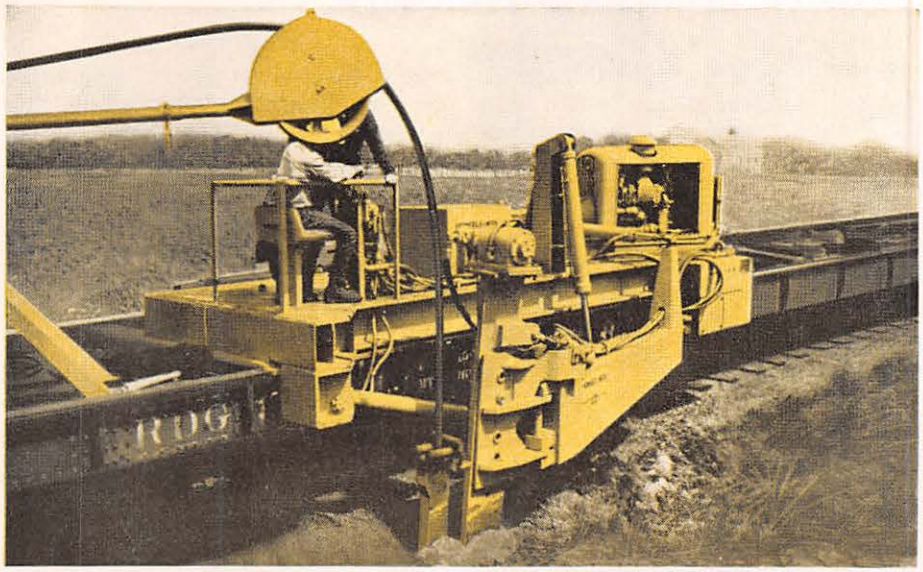

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Circle 14 on reader service card on page 38

tem with nonbridged paths for both directions of transmission from input to output. The use of precious metal contacts with attendant low noise and the inherent low shunt capacitance of the motor switch banks suit this system to the handling of data. Each switch has its own driving mechanism. The impactless drive reduces wear and noise to the extent that maintenance of the switch consists only of a speed test and lubrication once a year. The recessed vertical arrangement prevents accumulation of foreign particles and contributes significantly to the overall reliability of the system.

The 112 outlets of the bank are not subdivided into groups as is the case in two-motion switches. Trunk groups of various sizes are provided by marking the start of a group at any desired point of the bank. In this way it is possible to form groups of less than 10 outlets without wasting unused outlets in the group, and it is equally possible to provide for groups in excess of 10 outlets. At the same time the entire capacity of the bank is available when only a few, but very large groups are required or when more than 10 groups are required. This flexibility in utilization of the bank outlets will, in some instances, save selector ranks or will permit access to large trunk groups without resorting to grading with its lowered efficiency.

The system employs multifrequency signaling within and out of the office to control the motorswitch ranks. This, rather than the 10 pulses per second method was selected because of the speed advantages inherent in multifrequency signaling.

The motorswitch system consists of the following major equipment modules: Access Relay Set, Line Circuit, Link, Allotter, Register Sender, and Selector Control.

The access relay set is a high speed association circuit used to connect a PBX originating call to a register sender. Since the services of a register sender are required to control switching of calls through four-wire switching offices, every call entering the system is served by a register sender. In order to serve both local and carrier-connected exchanges, the access relay set has a four-wire transmission path and employs E & M signaling. It also provides a dial trap which detects dialing attempted prior to register sender association. If this occurs, the call is set to busy in the access relay set. Provision is made to meter these occurrences. Furthermore, any call encountering a final route busy is set to busy in the access relay set, so as to release the switched path forward and immediately make the links and channels available to other traffic. An access relay set

FIGURE 3

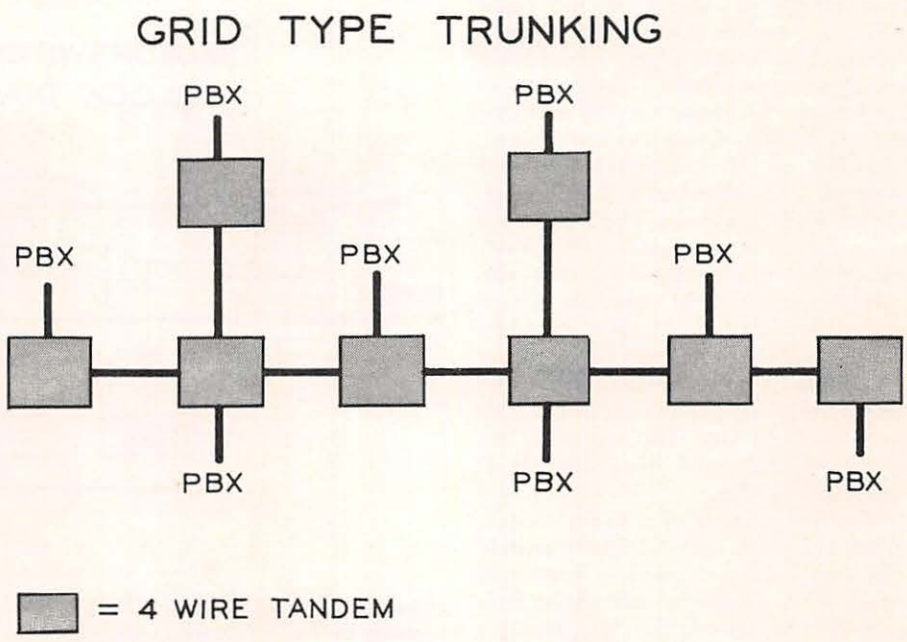


FIGURE 4

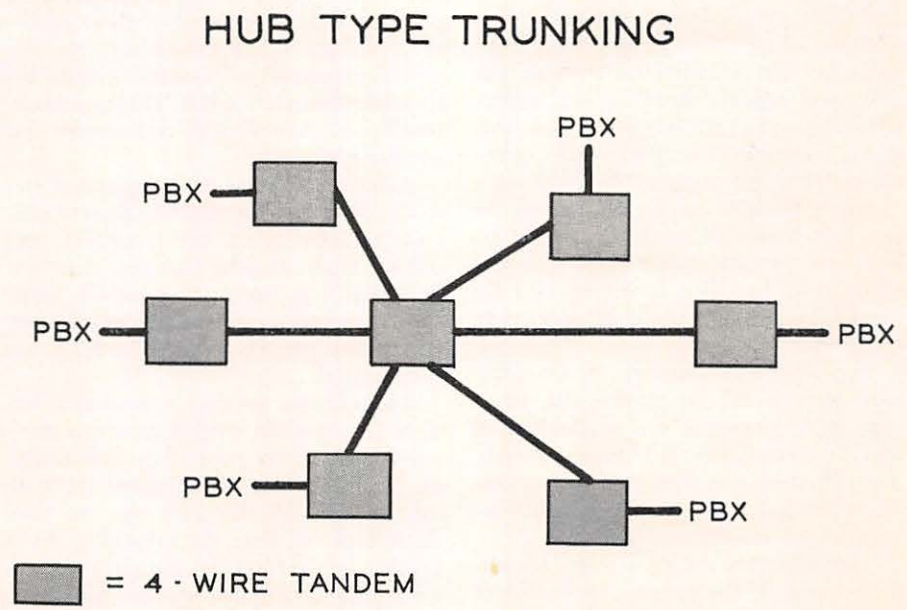
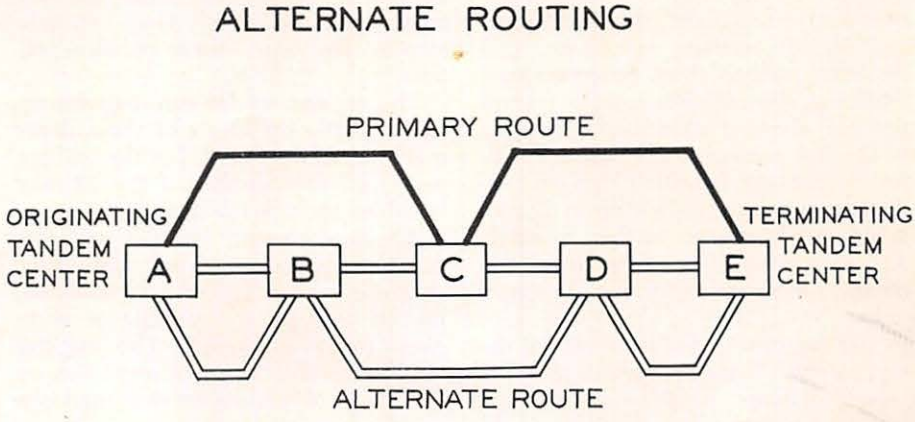


FIGURE 5



is required for each PBX trunk, message circuit or similar at the point where it connects to the 4-wire tandem switch. The design of the access relay set allows application of the access relay set and the register sender in existing step-by-step 4-wire tandem offices.

A line circuit function is required since all calls entering a 4-wire office appear on finder banks. The line circuit is similar to conventional line circuits except that it is arranged for four-wire operation and E & M signaling. A separate line circuit is not required when the call enters the four-wire switching system via an access relay set since the access relay set includes the line circuit function. One line circuit is required for each trunk from a remote 4-wire tandem office.

The link consists of a finder switch, a link relay set, and a selector switch. The link relay set provides means to cause either allotter to control the finder switch. It extends the MF signaling circuit to either of two selector control circuits and permits the selector control circuit to set the associated selector switch to an idle outlet in the desired outgoing trunk group. After selection of an idle outgoing trunk, the link relay set provides the transmission path, and repeats signaling and supervision between the incoming and outgoing channels. The finder and selector switches are arranged to work on a common bank in small offices and on separate banks in large offices. Since links are common servers, the quantity of links in an office is determined by the traffic and the grade of service to be provided.

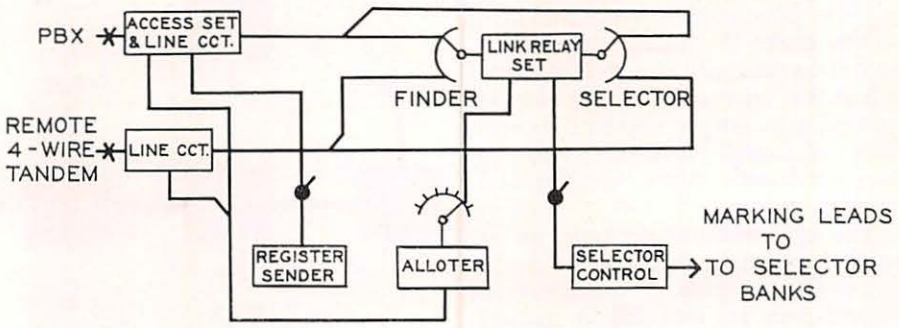
The allotter is another of the common circuits in the system. Its function is to preselect an available link and to control the link finder switch. Two allotters are equipped to provide the redundancy required to assure continuous and reliable operation.

The selector control is also a common circuit of the system. It consists of a relay set and a multifrequency signal detector. The circuit receives the multifrequency signals from the register sender, marks the selector switch banks and controls the setting of the selector switch in accordance with the signals received. In systems employing pad switching rather than common level switching, the selector control circuit provides the pad switching instruction to the link relay set. The selector control is arranged for either one- or two-digit operation to provide up to 37 outgoing trunk groups within a single switching stage. Two selector control circuits are provided for each group of links.

The register sender is of special design to provide the features required in private systems. Each sender has full

FIGURE 6

MOTORSWITCH • 4-WIRE
BLOCK DIAGRAM



capability for one- and two-digit examinations as well as limited capability for examination of the remaining four digits. Route treatment is provided in the form of route class relays. These route class relays are furnished in the form of plug-in modules for each register sender to reduce initial investment and to permit expansion of translating capability when the need arises. This approach results in considerable economies in smaller systems.

A unique scheme is incorporated into the design of the route treatment circuit to make for smooth transitions resulting from routing changes. Another provision has been made which permits temporary route changes, during emergency periods or the like by a remote signal.

The register sender is arranged for E & M signaling, and it provides storage for up to six subscriber-dialed digits. Translation is acomplished through examination of the first one or two digits received from the subscriber. Outpulsing can commence immediately after completion of translation. All digits required to control switching through tandem offices and into terminating offices can be outpulsed either in multifrequency or 10 pps dial pulse mode. Therefore, the register sender can accommodate networks which include step-by-step type 4-wire tandem offices.

The register sender can outpulse up to 12 digits. Up to six of these digits may be those dialed by the calling party and any number of the 12 may be added through translation.

Alternate routing facilities are provided to the extent of any number of alternate routes for each destination, limited only by the number of route class relays equipped. The register sender provides for route restriction on the basis of class-of-service markings received from the access relay set. Five different class markings are provided. One of these can be used to designate lines or trunks having a priority preemption privilege.

The register sender disposes of calls which cannot be completed through tandem offices due to trunk busy conditions or blockage for other reasons (such as incomplete dialing or incorrect codes). It does this by instructing the access relay set to release forward and apply busy tone. This eliminates unnecessary holding of interoffice trunks and tandem office links and results in an improvement in trunk efficiency.

Because the originating sender completes the connection, it is arranged to select alternate routes although the call has been extended into remote tandem offices. It is also arranged to block alternate routing once the connection has been extended beyond a specified point.

In order to reduce register sender holding time the register sender can be programmed to release from the call if register sender outpulsing catches up with the subscriber inpulsing.

In some instances networks include 2-wire exchanges where incoming trunk circuits are connected to line circuits In such cases it is customary to provide a stop-dial toward the register sender until a linefinder has been associated. A conversion of such 2-wire trunk circuits to add the stop-dial feature can be relatively costly. This register sender can be programmed to apply an extended interdigit interval at the appropriate time in order to allow sufficient time for the linefinding function.

The register sender has the standard features such as wink-start recognition, critical timing to determine end of dialing, noncritical timing, self-diagnostic failure detection and others.

A basic trunking diagram is shown in Figure 6. The calling subscriber dials a digit within the local PBX to access the outgoing E & M signaling trunk to the four-wire tandem center. A four-wire terminating set provides conversion from two-wire to four-wire operation. Seizure of the outgoing PBX trunk energizes the access relay set over the trunk M lead. The access relay set provides high-speed association with a register sender, avoiding the need for giving a second dial tone to the subscriber. The second and remaining subscriber-dialed digits are registered and stored by the register sender.

After receipt of the first or second digit by the register sender, the translation takes place and the register sender calls for a link. The start signal initiated by the register sender is extended via the access relay set to the allotter.

The allotter, having preselected a link, causes the high-speed link finder switch to connect to the circuit requesting service, which is marked by a potential on the finder bank.

When the access relay set has been found, the allotter is released and the link calls for a selector control. At this time the register sender already has applied the first digit in multifrequency form. The selector control converts this digit into a DC marking and applies it to the selector bank, marking the beginning of the outgoing trunk group. The selector control causes the nonhoming motorswitch to hunt for the group start marking and then tests for an idle outlet in the group.

When an idle trunk has been found, the selector control transmits a momentary off-hook signal to the register sender and releases from the link relay set. The link relay set seizes the line circuit associated with the outgoing channel and the seizure signal is extended via the transmission facility to the next tandem center, causing seizure of the line circuit there. Upon receipt of the momentary off-hook signal from the selector control, the register sender applies the next multifrequency signal, destined for the next tandem office.

The call can be advanced through multiple tandem centers in this manner. When the terminating tandem center is seized, the call is extended to the access relay set associated with a trunk into the terminating dial office. The register sender at the originating point then reverts to d-c dial pulsing to complete the call into the terminating dial office.

If intermediate or terminating tandem centers are of the step-by-step type, the register sender will provide 10 pps to them and, if necessary, revert to the MF mode for following tandem points.

If a call encounters a busy condition within a tandem center, a signal is returned to the register sender in the originating office which will then attempt to complete the call over designated alternate routes. If an alternate route is not available or if all alternate routes are busy, the register sender will cause the access relay set to return busy tone to the calling subscriber. The partially set-up connection is released, freeing the trunk facilities immediately for use by other calls.

When more than 10 trunk groups are required in one switching stage, the selector control circuit is equipped with one or more auxiliary circuits which allow the selector control circuit to accept two multifrequency digits. The first digit received denotes the supernumerary tens group and the second digit the desired trunk group. The selector switch is set to the marked group after receipt of the second digit by the selector control.

The basic system is designed to handle up to 100 trunks. When an office requires more than 100 trunks, two originating stages are provided and groups of second selectors are added. Second selector stages are equipped with their own selector controls and function in the same manner described. This provides growth to 200 trunks and further stages can be added.

Pre-emption is used in networks where specified callers must, because of the nature of their duties, be able to reach other parties within the network even though all trunks between tandem centers may be busy. Since it is not desirable to rely on the availability of links in any originating or terminating dial PBX in order to complete such calls, station line adapters are available to allow both calling and called stations to be connected directly to the four-wire center. The pre-emption privilege is a function of the class-of-service marking from the access relay set into the sender. This marking may be permanently wired or can be controlled by a key provided at the station instrument. Special inter-office trunk circuits are required for pre-emptible channels.

The register sender detects the class-of-service marking of a calling line having the pre-empt privilege and is programmed to transmit to each selector control a supernumerary multifrequency tone, followed by the compound digit tone.

Pre-emptible trunks have two points of access. The pre-empt access is marked idle by the selector control circuit as a result of receipt of the pre-emption tone. Seizure of the trunk from this appearance will occur whether the trunk is busy or idle. If the trunk is idle, the call is advanced in the normal manner. If the trunk is busy, seizure results in application of a tone to the circuit on which the subscribers to be pre-empted are in conversation. Subsequently the transmission path is opened and the pre-empted connection is released, allowing the priority call to be advanced. The priority call is advanced through succeeding offices in the same manner.

The fuse and equipment alarms are brought to a common point which provides a visual and audible indication of alarms. Alarms are subdivided into major and minor classes, and provision has been made to permit extension of the alarms to remote locations.

The motorswitch maintenance is limited to a speed check and lubrication if necessary. The speed check requires the use of only an oscilloscope. The register sender, link and selector control are tested by means of a portable test box. It permits rotary in-dialing to the sender, a digit-by-digit display of outpulsed information and a display of sender generated signals to the sender connected circuits. It allows for the insertion of class-of-service markings and provides controls to simulate ATB conditions to permit testing of all types of sender actions.

When testing a link circuit, the test box simulates the register sender, provides variable level multifrequency tone input via the link to the selector control and allows the link selector switch to be set to an idle trunk in the selected group. The test box provides multifrequency tone input at a variable level and a display of digit registered by the selector control sender test.

A reliability study of a 50 trunk office equipped with 25 links produced data indicating that routine maintenance action should be scheduled once every nine months. Mean-time-between-failure to complete one call due to equipment faults was calculated to be 15 years.

As mentioned previously, network dialing is based on seven digits maximum. The first digit is required in the PBX to reach the 4-wire tandem and the remaining six are received by the register sender. The first two of the six digits are used for translation. These two digits can be employed either as area or office codes. In most networks they are used as office codes, thus allowing for a maximum of 100 offices. It should be noted that each end office or individual trunk, such as subscribers connected directly to a 4-wire tandem and in some cases message circuits all require a separate office code. Thus the limit of 100 office codes allows an adequate but not unreasonable number of office codes for future growth.

In cases where the quantity of 100 office codes does not fulfill the requirements either initially or brought on by

(Please turn to page 36)

Railway Cybernetics

● High speed train operation is not confined to the Northeast Corridor trains in the U.S. Railways in Europe and Asia are also experimenting and running trains at upwards of 90-100 mph. *International Railway Journal*, a companion Simmons-Boardman magazine, published a report in June 1968 describing efforts made by these foreign railways. Below is an abstract from that article:

On Japanese National Railway's new Tokaido line, coded signal indications set speed and braking rates. Six speed settings are displayed in the driver's cab, ranging from 130 mph to full stop.

The driver actuates a master controller to move the train up to the desired speed. Once at top speed, the driver merely alternates between applying power and coasting, as appropriate, to accord with speeds restrictions transmitted by track frequencies.

Dynamic brakes come into play at one of three braking rates, depending on the speed of the moving train. In addition, air brakes are used at very low speeds and also as auxiliary brakes. There is an automatic braking application when signal indications are ignored.

Because of the total absence of level crossings or connections with other lines, engine drivers on the NTL have very little to do, and can maintain high average speeds.

Mitshubishi Electric, Toshiba, and Kyosan supplied all signaling and electronic controls, including CTC operated from a control center in Tokyo. The same center has centralized control of substations, supplied by Nippon Electric.

JNR researchers are also studying several types of waveguides (radar) that might be used in a moving block section system, to identify the exact position of a train out on the line.

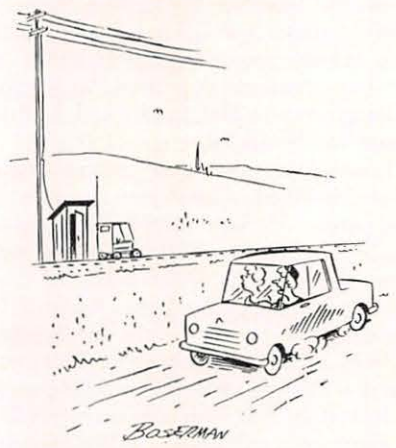
For Germany's Deutsche Bundesbahn's E 03 operation, Siemens supplied both power engineering components in the locomotive, and the electronic system that controls speed.

The throttle of the locomotive has a range of 12 speed settings from full stop up to 125 mph. With all cab signal indications clear, the driver can accelerate to top speeds in three minutes, assuming an eight-car train behind the locomotive.

The speed regulator "reads" signals up to 3.1 miles ahead of the train, and can maintain the correct speed regardless of gradients. Track frequencies change speed indications and Knorr electro-dynamic brakes are automatically applied, as appropriate.

Brown, Boveri did simulation of locomotive running, in connection with speed control for the E 03.

Both Siemens and Standard Elektrik Lorenz (SEL of the ITT group) have supplied DB with signal towers having all-relay interlockings, and electronic wheel detectors installed at trackside, in connection with raising speed on trunk routes. SEL also collaborated with an Indian manufacturer to supply Indian Railways with a system of cab signaling and speed control.



"It must have cost the railroad a fortune to put one every mile. Looks like he could wait 'til he got back to the depot."

When the SNCF (French National Railways) introduced a 125 mph speed for *Le Capitole* on a portion of the Paris-Toulouse line, it was not intended to make this line segment the exclusive domain of high-speed trains.

Wayside signals exist for the benefit of other trains, but a system of cab signalling and overspeed control applies to the high speed ones, with equipment supplied by Cie. des Freins et Signaux Westinghouse, J.M.S. and T.R.T. (Phillips).

There are two transmission channels between the track and the locomotive. One consists of magnetic pickup coils installed in the track. Selected track frequencies are used through this channel to transmit data as to profile of the line and the kind of controls to be exercised.

The other channel, a continuous or linear one, consists of coded frequencies from static transmitters installed in relay cases in the wayside signals, and picked up by coils fitted in front of the lead axle of the locomotive.

This channel transmits data on aspects of the signals farther down the line. Its main function is to either override and cancel the operating controls when signals read all clear or caution, or select the relevant control when several controls exist simultaneously in the same block section.

In the absence of any speed restriction, a permanent frequency is transmitted through track circuits which permits the driver to keep the throttle of his train at top speed. As in other systems of this nature, sound and light signals in the cab warn the driver of any change in speed restriction.

Since braking distance for a high speed train is necessarily long—1.5 miles is what the SNCF consider—the driver has three successive block sections (2.5 miles) within which to bring the train down to full stop. It takes two of these block sections to

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"Look around and see if I'm on the train. If not, please back up two miles and come get me."

bring the train down to 100 mph, and a full stop can be made in the third.

One change in the braking arrangements is that a push-button valve replaces the usual notches on a throttle.

More far-reaching investigations are going into other aspects of high speed operation. SNCF engineers are studying the use of channels other than the rails themselves or fixed coils for transmission of data needed for speed and in braking indications. The carrier proposed and under study would be an auxiliary cable fastened to the track sleepers (ties).

One more aspect under investigation is development of servo-systems which would accurately brake a train without intervention by the driver. A number of such devices have been introduced in special environments—mining railways and underground railways—where operations are of their nature more limited than on main-line-rail routes.

When British Rail electrified the Midland Region trunk route between London, Manchester and Liverpool, a complete resignaling of the line was also done.

Equipment for this was supplied by AEI-GS (Associated Electrical Industries-General Signal), Westinghouse Brake & Signal and SGE.

A crucial aspect as far as the higher speed ranges is concerned is that an automatic warning system was instituted that involves track circuits and certain cab signal indications.

Wayside signals exist in the form of multi-aspect color light signals. However, intead of the driver reading them, a pair of inductors at the approach to each signal transmits frequencies to the locomotive cab. If speed restrictions so dictate, a "Stop" or "caution" aspect sets off a warning horn in the cab. If the driver fails to acknowledge it, the brakes are applied automatically.

Also to be mentioned in connection with high speed operation in Britain is the work done by AEI and English Electric in the power engineering field for fast multiple-unit trainsets and electric locomotives.

Thyristor controls developed by these firms have a number of applications—among them possible use in driver-less trains in which the required motor current is set automatically in response to information received from outside.

Soviet Union passenger train speeds of 81 mph or more are becoming quite common, and on the Moscow-Leningrad line, speeds sometimes reach 100 mph.

In test runs, still higher speeds have been achieved, and the Russians have made important advances in theoretical design work for computers as well as installation of radio control and track-frequency speed control of locomotives. The general trend is not so much toward achieving a very high speed on one or two lines, as to effect a general increase in average speeds on many trunk routes.

Looming in the background is the new role of the computer in ordering railway operation, in particular high speed operation.

Logic devices of various sorts are already used in relay interlockings, wayside equipment and train-carried equipment to compare pre-set schedules and speeds with those actually being carried out, and then institute warning or corrective action.

The next step becomes creation of total systems in which many different functions are integrated. JNR are already close to this in their Tokyo center for the NTL, where CTC, automatic train driving, central control of sub-stations are closely linked, and automatic reservation system exists.

Here, as elsewhere, railways are exploring methods for hooking all operating functions to a single master data bank, where norms of the operation are established, initiated, and supervised.

Researchers in the Soviet Union report work on an "auto-dispatcher" which may achieve something close to total control of all movement on a line.

There are four flows of information to the auto-dispatcher: (a) from track circuits and through CTC channels; (b) from station points and light signals through CTC codes; (c) from the dispatcher at his desk; (d) from the main station operators.

A fifth flow of information could be between two control machines operating in parallel.

The auto-dispatcher thus becomes a seven-part system with these component parts: (a) Control computers (usually two units); (b) CTC; (c) Junction transfer installations; (d) Dispatcher's desk equipment, including master controller, separate indicating panel, two train recorders (current and planned graphs), print-out device for printing dispatcher's logbook and train movement statistics; (e) Communication apparatus with main station operators—illuminated panel plus roll teletype; (f) control equipment for parallel working of two machines; (g) Software—programmes and sub-programmes, mounted partly at the control centre, partly at station installations and partly along the line.

To the first two controlled groups of elements the auto-dispatcher delivers orders to be carried out, and supervises the execution of them. In relations to station operators the control centre retains relative priority, assigning operating plans.

Relations between the controlling machine and the dispatcher can be adjusted as desired, so that the machine could be put on advisory, semi-automatic, or fully automatic duty.

The overall aim—a big increase in train speed and centralized control.

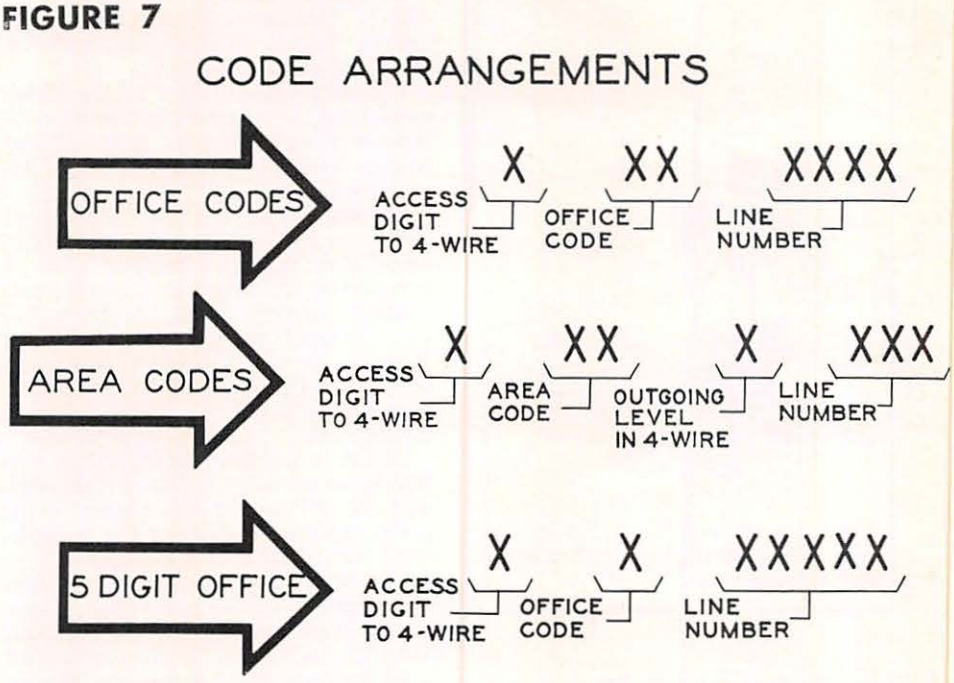
(Continued from page 33)

unexpected growth, the numbering plan for the system can be arranged or changed so that each 4-wire tandem exchange can be assigned a two-digit code. In this case the code can be called an area code and used to designate a group of exchanges which home on the 4-wire tandem. With this arrangement it is necessary to use the fourth digit from the last to designate the level on which the trunks to the terminating exchange are located.

As shown in Figure 7 this allows for up to 10 offices per area code but does not allow for a terminating exchange requiring four digits. In actual practice two area codes are required for a tandem center having two selector stages. One code is used for all exchanges reached via the first rank of selectors; the second code permits generation of the required additional routing digit to extend the call into the second rank of selectors. The fourth from the last digit is employed to designate the level on which the trunks to the terminating exchange are located. A four-digit terminating exchange must be given its own code to permit routing of the call into the exchange without use of any of the last four digits since they must all be sent into the terminating office.

Finally, a five-digit office can be accommodated by using the first digit of the code alone, sending the remaining five digits into the terminating office. This usage will, of course, block use of the nine other possible codes starting with the same first digit. In this way the numbering plan can be arranged to meet the needs of the network, allowing for up to 1,000 offices.

FIGURE 7



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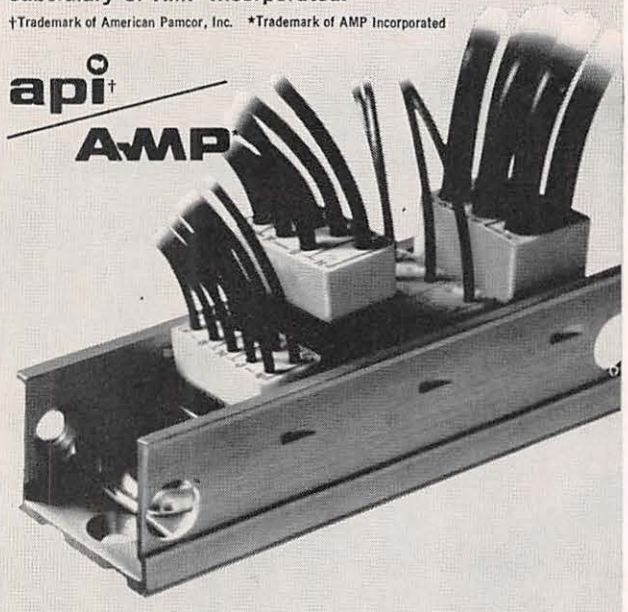

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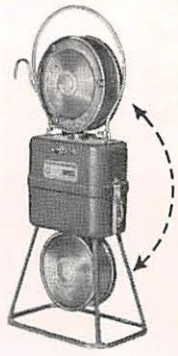

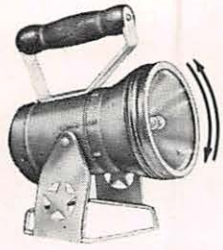

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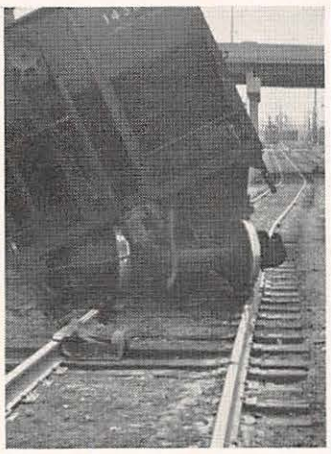

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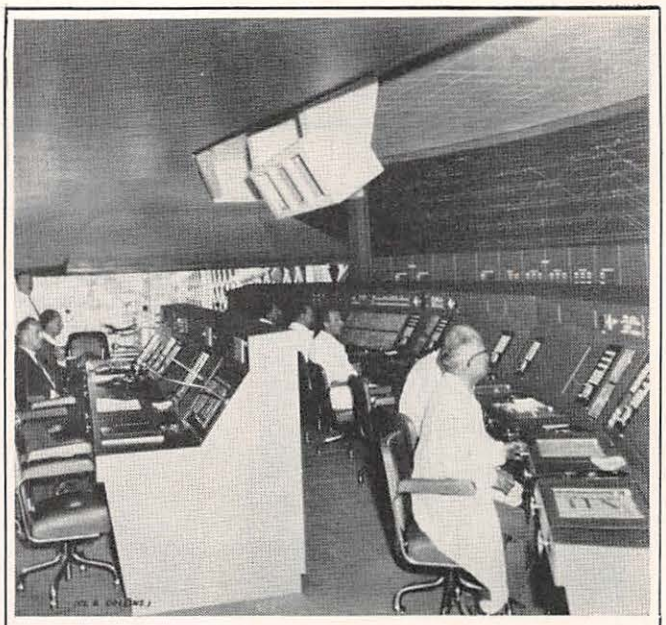

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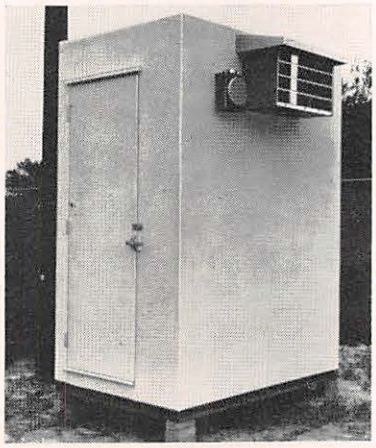
Product News



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The receiver is a solid-state device which can be housed within the standard signal case or in a box mounted on the signal standard with the flashing lights at the crossing. The receiver is connected to the rails by a single wire to each, a power source and the flashing lights and gates plus relay logic for bi-directional operation. The receiver, also, has built-in surge protection. The receiver receives excitation from the transmitter (in the absence of a train) and keeps the lights or gates inactivated. When a train shorts the transmitter, the receiver receives no excitation and the lights or gates will be activated.

The relay logic provides the island logic for bi-directional installations (for unidirectional installations, only a transmitter and receiver are required). The relay logic automatically switches the crossing island to the approach direction and disables the approach from the opposite direction. It clears the crossing as soon as the last car of the train has cleared the island. *Marquardt Industrial Products Co. Circle 102 on Reader Service Coupon.*

• MICROWAVE operating in the 2,000 mHz frequency band features solid state equipment including RF switching and 300 channel capacity. The A302 system is described in a brochure with a technical summary including electrical specifications. *Telecommunications Division ITT. Circle 103 on Reader Service Coupon.*

Railway Signaling & Communications

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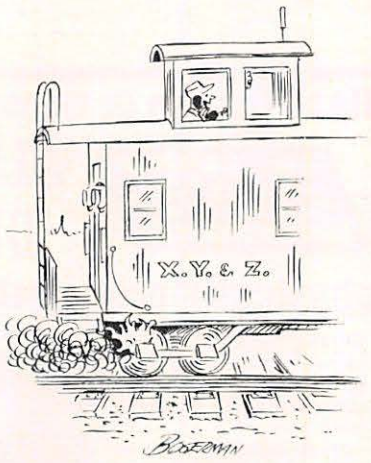

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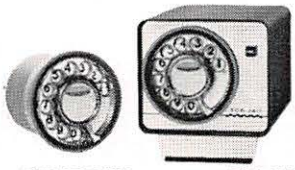

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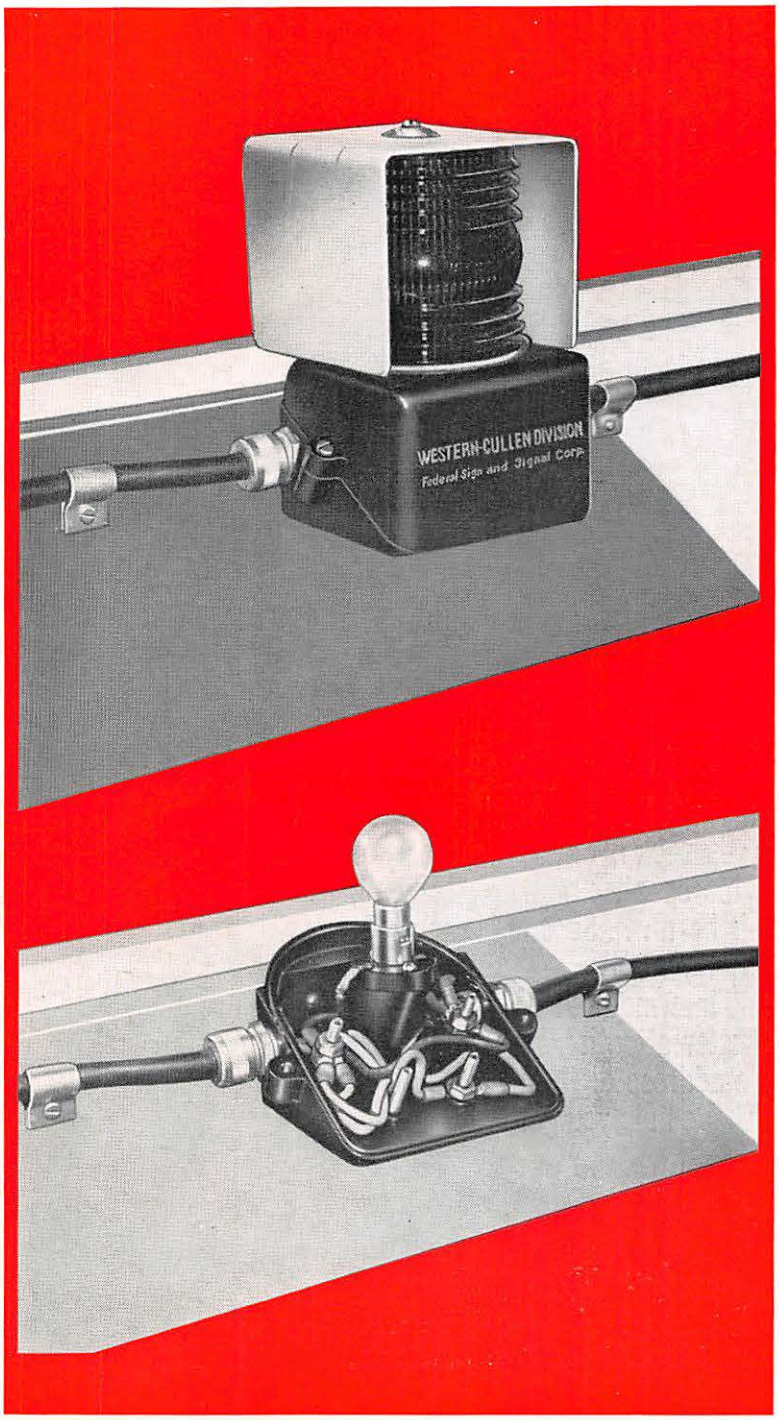

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